THE

Indian Tea Association.

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL.

PART II.

1925.

Calcutta:
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CORRIGENDUM NOTE.

An error appears to have crept in the text in the Note " How to take samples of soil " in Part IV of the Quarterly Journal for 1924. It states that "about a pound weight of soil is required "— this should read " about a five pounds weight of soil is required."

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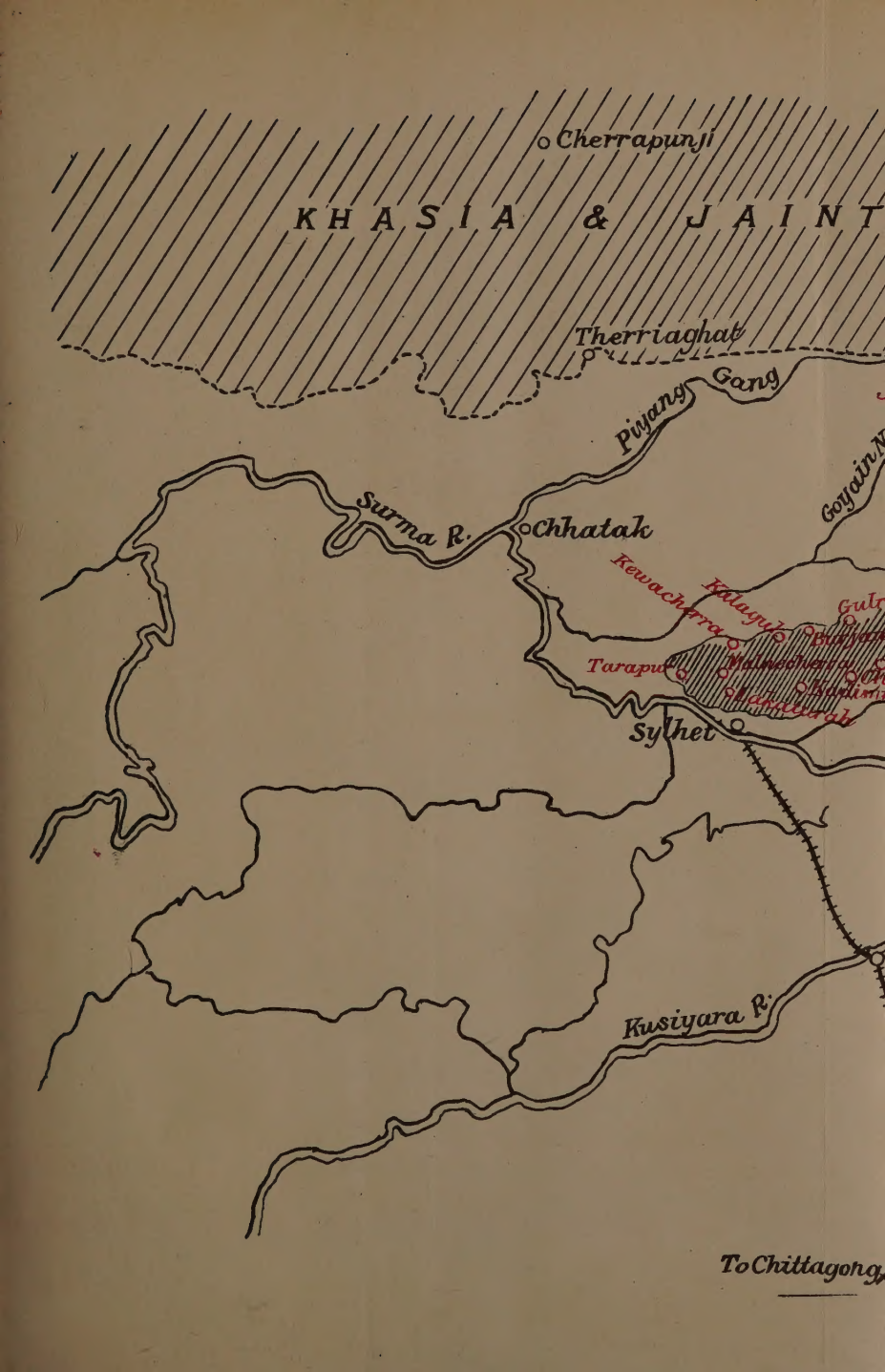
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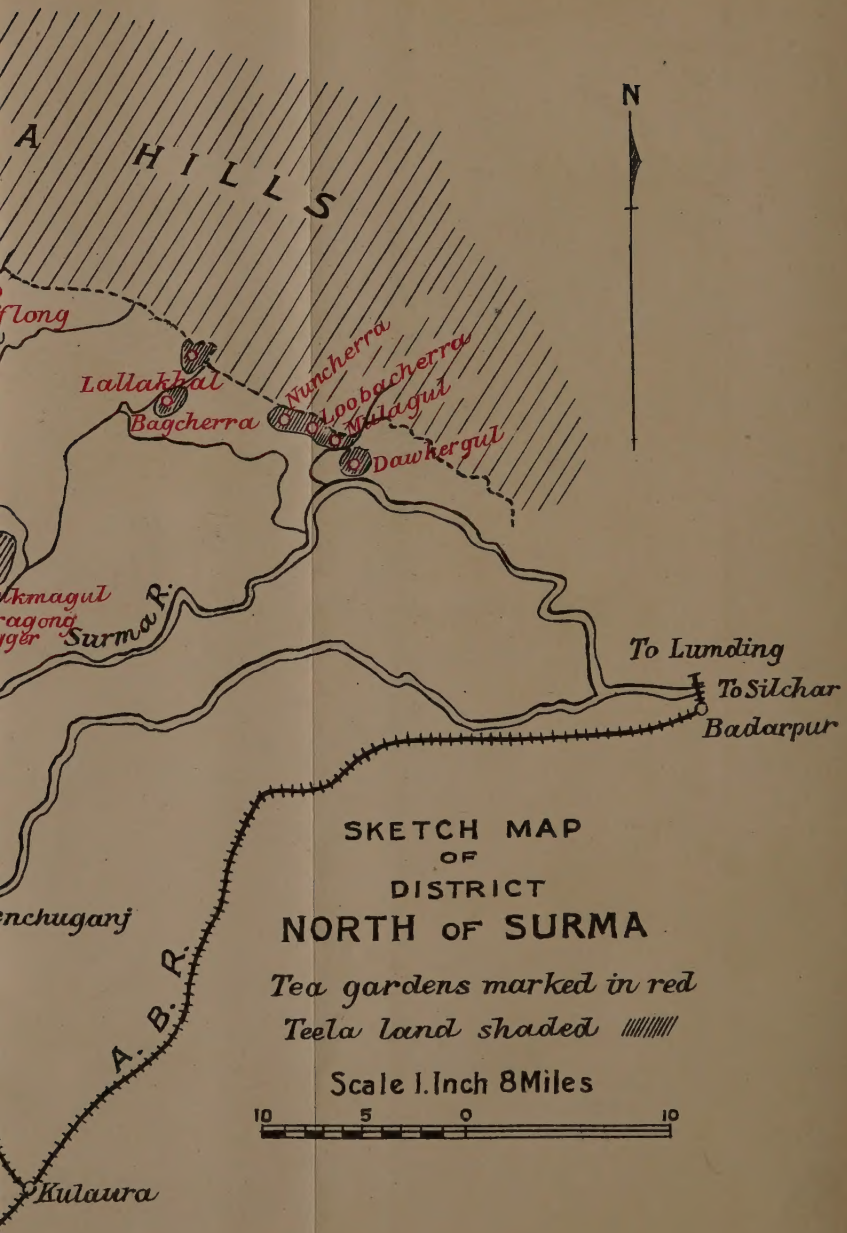
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A. B. R.
Kulaura
SKETCH MAP
OF
DISTRICT
NORTH OF SURMA
Tea gardens marked in red
Teela land shaded
Scale 1. Inch 8 Miles
10 5 0 10

THE DISTRICT NORTH OF SURMA

BY

C. R. HARLER.

Geography.

The district North of Surma or North Sylhet consists of about 7,000 acres of tea planted out on the teelahs near the town of Sylhet, and under the Khasia Hills.

In North Sylhet there is an infinite number of bheels connected by a network of rivers which fork and join again in a manner bearing witness to the flatness of the country. The only hills are a series of low teelas forming an "island" of red soil stretching from Sylhet town in a north-westerly direction for about thirteen miles. The teela land is from three to four miles wide and seldom reaches an altitude of 300 feet. In this area the Lackatoorah, Lulleecherra and Malnicherra gardens are put out together with two or three smaller Indian-owned gardens.

The teelas are of the same geological formation as those of South Sylhet, being Tipam sandstones belonging to the Tertiary period in geology. They are of much greater age than the alluvium of the plains.

In the dry weather the rivers flow in deep beds, but in the rains they usually overflow the banks which are higher than the surrounding country. The slope of the country is so small and the outlet of the rivers so restricted by the waters of the Ganges that at all seasons the rivers resemble slack water canals.

The Surma and the Barak flow into the Megna which at one time joined the Brahmaputra below Dacca when the latter river flowed east of the elevated tract of country known as the Madupur Jungle. Although the Megna is by far the smaller river, it receives its waters much earlier than the Brahmaputra. Thus the heavy rainfall along the southern face of the Shillong plateau causes an early rise in the Megna whilst the big river is still waiting for the snow waters of the Himalayas and the more moderate

rainfall of the Assam Valley. On this account the Brahmaputra when it flowed in its old bed was held up during the earlier months of the monsoon.

The slope of the Brahmaputra is generally more than six inches to the mile and on this account most of the silt is carried along with the river to be deposited in its lower reaches. Now formerly this river overflowed each year into the Sylhet bheels with the result that they were gradually silting up. With each succeeding year, however, the Brahmaputra was building a higher bank for itself and the annual overflowing into Sylhet became more and more difficult. Finally, the river was damned in an aqueduct of its own making and was forced to find a fresh outlet. Any movement westwards was impossible owing to the Madupur jungle, so the only alternative was to retrace its course and to join the Jamuna above Diwanganj, 70 miles to the north, leaving its old bed a mere string of pools. With the big river sent back through its distributaries the Megna was left in sole charge of the old course below Dacca. The result is bad for Sylhet, for the possibility of silting up the bheels is now very small since the waters flowing from the well-washed Shillong plateau carry practically no silt.*

The northern boundary of North Sylhet is formed by the Shillong Plateau rising precipitously out of the plain. Right to the edge of this range of hills the preponderating influence of the Brahmaputra is seen from the alluvial deposits. The Shillong Plateau consisting of ancient quartzites, schists and slates with masses of granite is overlain by sandstones of a much later period. These latter are overlain by Eocene limestone from which deposits the well-known Sylhet limestone is obtained. This product is quarried in the foothills and ground in Sylhet and contains over 95 per cent. carbonate of lime, about 1.5 per cent. carbonate of magnesia and about 1.5 per cent. oxides of iron and alumina.

* Himalayan Journal—Vol. II, Dr. Hooker.
Q. J. Geog. Soc. Lond.—Vol. XIX, p. 321, Fergusson.
Mem. Geol. Sur. Ind.—Vol. VII, pt. I, Medlicott.

The Climate.

The climate of Sylhet differs considerably from that of Assam. During the first months of the year the maximum temperatures are about 7°F higher than in Assam, although during the monsoon they are about the same in both valleys. During October, November and December, the maxima in Sylhet are above those of Assam by 4°F early on, to about 8°F at the end of the year.

The rainfall is heavy, but the distribution is bad and spring droughts are the rule. In spite of the early rain shortage combined with high temperatures the tea put out on sandy teelahs looks remarkably well at the end of a drought. This is no doubt attributable to the fine root development of the bushes on these light soils.

The table below shows the average monthly rainfall at Jafflong, situated right under the Shillong plateau a few miles west of Cherrapunji, and Kadimnugger, as representing the teela area of the district North of Surma. The average total rainfall in the valleys of South Sylhet is about 110 inches and of Silchar about 120 inches.

Rainfall at Jafflong and Kadimnugger.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Jafflong	0·7	0·9	8·2	19·3	27·6	60·4	49·6	40·6	32·6	13·5	1·1	0·4	254·6
Kadim-nugger	0·7	0·8	4·6	15·9	13·6	35·1	24·5	24·8	21·0	12·9	0·3	nil.	155·3

One effect of the early drought is that the season starts somewhat later than in the Assam Valley, although owing to the higher autumn temperatures plucking usually continues till the end of December.

The early drought produces a *banjhi* period at the beginning of the season. In Sylhet the *banjhi* shoot is broken back unless the drought is so severe, and the spring growth is held up so early, that the *banjhi* appears much below the plucking surface.

In March and April Sylhet is subject to winds known as *tufans* blowing from the north-west of the Assam range. They result from the heating of the plains followed by the drawing in of the air from cooler regions. Hail storms are frequent during this period.

The Soils of North of Surma.

The soils on the teelas of North Sylhet are generally very sandy and contain only small percentages of clay. At Kadimnugger, which, like most of the gardens round about, consists mainly of teelas and narrow flats, the following analyses were obtained. The values are percentages.

Soil.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
No. 2, Teela top	47	25	8	12	4	4·28	1, 2, 4, 3, 5
No. 2, Half way up teela	55	18	7	11	4	4·08	1, 2, 4, 3, 5
No. 2, Flat	50	18	7	14	3	5·09	1, 2, 4, 3, 5

These three samples were taken in order to observe the effect of soil erosion if any. Any difference in the soil analyses is so small that it may be concluded that all three samples represent the same soil and that there has been practically no washing. The problem of soil washing is naturally a major one in teela country, and although erosion is reduced by terracing it often happens that the steepness of the slope necessitates such a long step between terraces that the great loss of moisture by evaporation from the exposed surface greatly intensifies the effect of the drought. If such steep slopes are planted, close, regular planting gives better results than terraces. In Java, terraces are formed naturally by growing Boga medeloa round the contour and allowing the stumps to collect soil wash. Regarding the cultivation of slopes, it has been noticed in Ceylon and elsewhere that the deeper the cultivation the less the soil wash. This will be readily understood when it is considered that a good deep hoe leaves a layer of soil capable of absorbing rain without itself being washed away.

At Cherragong, an outgarden of Kadimnugger, the subsoil from the foot of a teela and that from a rice flat showed the following analyses.

	Coarse sand	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil Type.
Rice flat subsoil	34	37	8	12	4	3·69	2, 1, 4, 3, 5
Teela subsoil	55	22	6	8	4	3·85	1, 2, 4, 3, 5

The rice flat looks like a soil slightly water-sorted from the teela, although the slope of the flat is too small to allow of any fundamental change in the soil type by washing.

Part of Cherragong is put out under sisal which does well but poles a year earlier than is usual in dryer climates.

At Kalagul and Burjan, two other out-gardens of Kadimnugger, the following analyses were obtained.

	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil Type.
Kalagul-typical flat	35	45	6	7	5	2·52	2, 1, 4, 3, 5
Burjan-teela top	66	22	5	3	1	3·11	1, 2, 3, 4, 5

All these soils are open and friable and at the end of a drought, in spite of the fact that the soil dries out to a depth of about 18 inches, the bushes still look healthy and the leaves turgid, owing to the deep rooting system. When bushes are once established on sands a normal drought does little harm. The putting out of young tea on such soils is, however, a gamble with the weather for a new clearance meeting with two or three bad seasons during its early years, seldom makes a first class area. Other soils on the Kadimnugger gardens include the types :—

1, 2, 3, 4, 5 (4 examples)
1, 2, 4, 3, 5
2, 1, 4, 3, 5

all containing at least 60 per cent. coarse and fine sand.

At Malnicherra the valleys between the teelas, especially those facing the flat lands of Sylhet, are often composed of newer alluvium either washed down from the hills or, more probably, deposited from the plains as the flood waters backed up to the teelas.

The following types occur at Malnicherra :—

Section.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Frankthol	26	28	20	7	8	8·49	2, 1, 3, 5, 4
Podibhil	40	22	17	6	7	5·85	1, 2, 3, 5, 4
Avangi	53	22	11	4·5	4	3·46	1, 2. 3, 4, 5

The section Frankthol carries the best tea in the garden and it is significant that here the loss on ignition is much higher than in the other sections and the soluble humus is 2.38 per cent. against about 1 per cent. elsewhere. Frankthol is a red soil but the others are getting towards the low end of the garden and are not so red owing to the influence of new alluvium.

At Hilwacherra, an out-garden, the types :—

1, 2, 3, 4, 5 (2 examples)

1, 2, 3, 5, 4

are found.

All the sandy teela soils require such treatment as will tend to bind the soil and restrict the loss of moisture during the drought. For this purpose, organic matter such as well-rotted cattle manure, green crops and bheel soil, if available, should be applied. Unfortunately there are no bheels in North Sylhet, although occasionally a small pocket of bheel soil is found. The absence of bheels is probably due to the fact that the valleys or *kunchis* between the teelas are not deep enough to allow water to back up and settle. A bheel is a settling tank grown with weeds.

A suitable complete mixture for the sandy teelas is as follows :—

200 lbs. fish guano or ordinary animal meal
80 lbs. sulphate of amonia
40 lbs. muriate of potash

per acre, applied, for preference, in April.

From Lackatoorah and its out-garden Kewacherra there is unfortunately only one analysis available which is, however, not typical. It shows a clay of the type 4, 5, 3, 1, 2 with 40 per cent. fine silt and 18 per cent. clay.

It frequently happens that small areas of flats, slightly depressed, carry poor tea, and in spite of careful lateral drainage the bushes seldom improve. Generally a shallow protection drain round the top of the slope greatly improves matters, for most tea soils are able to cope with and dispose of the rain which falls on them but are unable to deal with surface wash in addition. A protection drain stops such wash.

Jafflong is a garden put out on the flat at the foot of the Khasia Hills. On the opposite bank of the Piyain Gang, the northern boundary, the red sandstone hills rise steeply and as might be expected, red soil is seldom far below the surface soil of the garden. The predominating type is :—

2, 1, 3, 4, 5 (sections Nos. 1, 3, 6 and 12)

but heavier soils of the type :—

2, 3, 1, 4, 5
3, 2, 1, 4, 5

occur on sections Nos. 30 and 26 respectively.

Two samples of soil were taken from an area where there was a black sand, looking like a new soil, overlying a bright red subsoil of what appeared to be a much earlier formation. The analyses are as follows :—

Section.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
No. 23, top soil	3	61	16	13	2	5·37	2, 3, 4, 1, 5
No. 23, subsoil	6	58	17	10	5	3·97	2, 3, 4, 1, 5

The mechanical analyses are almost indentical and both soils are probably of the same origin. The blackness of the top soil is common where grazing land is burnt each year and such blackness persists for a great number of years.

From the out-gardens of Jafflong, Bagcherra and Lallakhal, no analyses are available but those gardens consist of sandy red teelas and clay flats.

Loobacherra with its out-gardens is put out on teelas close to the foot of the hills. The following values are given :—

Section.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
No. 3 flat	8	21	18	30	16	4·58	4, 2, 3, 5, 1
Sandy teela	6	27	12	20	26	5·25	2, 5, 4, 3, 1
Mongalpore flat	13	39	14	15	11	5·09	2, 4, 3, 1, 5
Plateau land	20	35	9	8	18	5·14	2, 1, 5, 3, 4

Of these soils, the plateau land is preferable, containing as it does a good percentage of clay to steady up the water movement in the soil, and a fair quantity of sand to keep the soil open and friable.

SOME NOTES ON TEA DISEASES CAUSED BY *CORTICIUM* Spp.

BY

A. C. TUNSTALL.

During the last few seasons diseases of tea caused by various species of *Corticium* have been increasingly prevalent in North-East India. The commonest *Corticium* causes a disease which is locally known as Black Rot. This was previously referred to in this Journal. (1917, p. 80.) It was then assumed to be caused by the same fungus that causes a similar disease in Java and in Ceylon. This fungus was described by Bernard as *Hypochnus Theae*, the name was later changed to *Corticium Theae*. It was found however that the fungus causing the disease in North-East India differed in some important details from *Corticium Theae* Bern and more closely resembled *Corticium invisum* Petch which is found in Ceylon.

Black Rot.

The disease known as Black Rot in North-East India causes irregular brown patches on the leaves similar to those produced by Thread blight, but no threads are visible to the naked eye. When the weather is wet the diseased leaves are often black and the younger ones become rotten and slimy. The diseased leaves do not fall off but remain attached to the stems and to each other at points of contact by a small cushion of fungus mycelium. Occasionally they may be found hanging by a tiny thread or two like those of a spider's web. The spots on the leaves are at first small, enlarging later to large brown or chocolate-brown patches resembling those caused by Brown and Grey blights. On light coloured thin leaves the spots are frequently light in colour with a dark margin.

The fungus mycelium is wholly external and confined to the green portions of the plant. Under ordinary conditions it is invisible but if a diseased shoot be kept in a moist chamber for a few days the fungus may grow sufficiently to be visible as a white or cream-coloured weft on the surface of the leaves, forming a cobwebby mass in the axils. The mycelium is many septate and much branched, at first colourless, becoming cream-coloured with age.

The fructifications arise on the under surface of apparently healthy leaves. They appear as powdery white patches. The patches are usually inconspicuous and in this respect appear to differ from those produced by *Corticium invisum* Petch, in Ceylon. The spores are borne on short sterigmata arising from short club-shaped basidia. As a rule there are four spores on each basidium. One or more basidia arise at the end of a single hypha. The spores are ob-ovoid slightly curved on one side near the base. The size of the spores appears to vary considerably. For instance spores collected in July 1919 averaged 10.9 by 6.2 μ. Others collected in June 1925 averaged $7.6 \pm .06$ by $5 \pm .04$ μ. In both cases the spores were mature.

The loss caused by the disease is not at first apparent as a healthy tea bush is able to lose a lot of leaf without serious effects. The damage to the leaves often stimulates the production of new leaves and the bush may actually yield more crop for a short time. In time however even the most vigorous bushes suffer and go back seriously. Where the bushes are already in poor condition the loss is more quickly apparent. On some gardens very serious loss has been caused by this disease and it is obviously desirable to take steps to keep this disease in check wherever it is found.

The fungus is not difficult to treat as it is wholly external throughout its life history. The application of any fungicidal solution appears to kill it. Lime-sulphur solution has been used repeatedly with marked success. The chief difficulty

Corticium Sp. 1.

The small white patches are formed on the living stem.

in regard to the treatment of this disease is the rapidity with which it spreads under favourable conditions and it is most important to isolate and treat any patch of infected bushes as soon as they are observed.

Corticium Theae Bern.

Specimens of tea shoots bearing the mycelium resembling the description of *Corticium Theae* Bern have been observed from time to time in North-East India but so far no fructifications have been found.

Corticium Sp. 1.

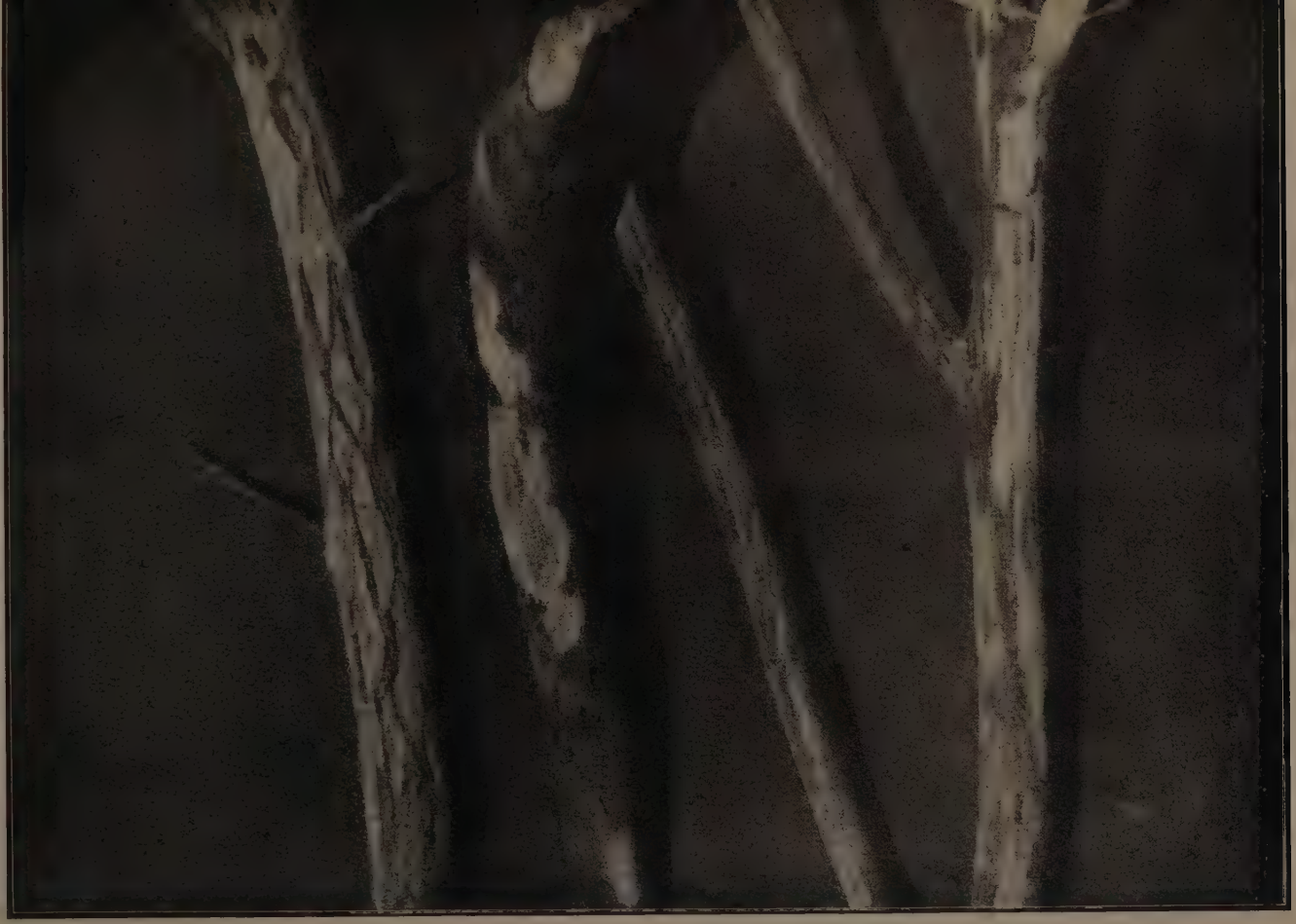
During the last two years a new disease has appeared mostly on gardens bordering the Hymalayas. This is caused by another species of *Corticium* somewhat resembling that which causes Pink Disease of rubber, *Corticium salmonicolor* B. & Br. ; but differing in some details. For instance : the spores differ from those of *Corticium salmonicolor* B. & Br. the latter are usually flattened in one plane. The measurements of the breadth of such spores show a greater variation than that observed in the specimens under notice. The fungus attacks the brown bark of the young wood, bleaching it. The dead strips of bark on the outside of this wood are usually unattacked and in consequence remain their normal colour emphasizing the whiteness of the bleached areas beneath. The fungus usually starts at forks on the young woody stems and spreads thence until the whole of the brown bark is bleached, it then sometimes extends to the bark of the older stems but so far has not been found on the green shoots.

The fructifications are white or pinkish patches ⅛ inch to ¼ inch in diameter usually produced just below forks on the younger brown twigs. The basidia are long club-shaped bodies bearing two or four sterigmata at the end of which the spores are produced. The spores are oblong and colourless.

The following are the measurements of spores :—

Number of count.	Length.	Breadth.	Number of count.	Length.	Breadth.
1	9·1μ	5·5μ	22	10·4μ	5·2μ
2	9·1μ	5·2μ	23	10·4μ	5·2μ
3	10·4μ	5·2μ	24	10·4μ	5·5μ
4	10·4μ	5·5μ	25	9·8μ	5·5μ
5	10·79μ	5·6μ	26	7·8μ	5·2μ
6	10·4μ	5·2μ	27	10·4μ	5·2μ
7	9·1μ	5·2μ	28	10·4μ	5·2μ
8	10·4μ	5·5μ	29	10·4μ	5·2μ
9	10·4μ	5·2μ	30	10·4μ	5·2μ
10	10·4μ	5·2μ	31	10·4μ	5·2μ
11	10·4μ	5·5μ	32	10·4μ	5·2μ
12	9·1μ	5·8μ	33	10·4μ	5·5μ
13	10·4μ	5·8μ	34	10·4μ	5·2μ
14	9·1μ	5·5μ	35	9·1μ	5·2μ
15	11·7μ	5·5μ	36	10·4μ	5·2μ
16	10·4μ	5·2μ	37	11·0μ	5·5μ
17	9·1μ	5·5μ	38	10·4μ	5·2μ
18	10·4μ	5·2μ	39	10·4μ	5·2μ
19	9·1μ	5·2μ	40	10·4μ	5·2μ
20	9·1μ	5·2μ	41	10·4μ	5·2μ
21	10·4μ	5·2μ	Average	10·1μ	5·3μ
			Probable error	±·07μ	±·018μ

The fungus apparently causes little immediate damage on vigorous tea bushes but wherever conditions have been unfavourable to the tea plant it has caused serious loss. The tea at Tocklai was infected accidentally from specimens received from the Terai. In the course of a few weeks the whole area was infected, not a single bush escaped. The fungus fruited freely within two months and ample material was readily available for study. In spite of this general infection the tea remained vigorous. After pruning, the prunings were burned and some time later the whole area was sprayed thoroughly with Lime-sulphur solution with the exception of a small area treated with



Corticium Sp. 1.

The stems on the extreme right and left are attacked by this fungus.

Corticium Sp. 2.

The white or pinkish patches are formed on the small dead twigs.

Burgundy mixture. Both fungicides were effective and the disease disappeared from all the bushes with the exception of about half a dozen. These have been left untreated so that the further progress of the disease may be observed on them. So far although these bushes are distinctly behind the others and a few of the weaker stems have died back they are far from becoming moribund.

Corticium Sp. 2.

During the investigation of *Corticium Sp.* 1. another *Corticium* was frequently found on dead twigs on the same bushes. This *Corticium* forms fructifications somewhat larger in area than those of the parasitic species. They are white patches bearing basidia twice as long as those of *Corticium Sp.* 1. The spores are the same length but twice as broad. It is obviously quite a distinct species. It appears to be purely saprophytic.

Other species of *Corticium*.

Besides the abovementioned species there is another species in Cachar and Sylhet. This species kills patches of bark, causing cankerous growths. So far no satisfactory fructifications have been obtained but from other characteristics it is probably Pink Disease, *Corticium salmonicolor* B & Br. It is not very common.

The treatment of *Corticium* Spp.

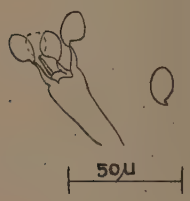
The species of *Corticium* which is doing the most damage is undoubtedly that which produces Black Rot. This species is fortunately wholly external and one thorough application of Lime-sulphur solution is sufficient to kill it right out. Unfortunately it is impossible to spray large areas quickly and if the disease becomes general it is impossible to do much until the tea is pruned in the cold weather. If however the disease is recognised while it is still confined to small areas it is a comparatively simple matter to eradicate it. The first thing to do is to isolate the areas, because coolies, cattle, etc., in pushing their way

through the tea, rub off small pieces of mycelium, to say nothing of spores, and carry them to uninfected areas. A few lines of apparently healthy bushes should be included in the isolated area. If the outbreak is on a small section it is as well to isolate and treat the whole section. Next spray the bushes thoroughly with Lime-sulphur solution commencing operations on the healthy tea round the edges. In the case of a number of outbreaks occurring simultaneously treat the small scattered areas first. If there is any doubt about the thoroughness of the spraying this operation should be repeated as soon as possible.

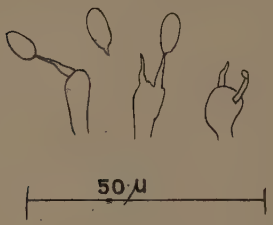
The other important species is the one I have referred to as *Corticium* Sp. 1. In this case the fungus is within and between the cells of the bark and to be effective it is necessary for the spray fluid to penetrate this layer. Fortunately wherever the fungus has attacked the bark the latter is rendered much more permeable and there is no doubt that the Lime-sulphur solution penetrates to a sufficient extent to kill at any rate most of the fungus if the fluid be used in sufficient concentration.

The most feasible method of treating this disease is to postpone operations until after the pruning. A smaller quantity of solution is then required and further the solution may be used more concentrated. As the fungus is within the tissues and there is no evidence to show that it cannot survive for a considerable time on prunings it is desirable to burn prunings within a reasonable time of pruning. From our experience at Tocklai it would appear that one application of sufficiently strong Lime-sulphur solution thoroughly well applied in the cold weather after pruning is sufficient to keep the disease in check. In addition to the special treatment described above, attention to the general health of the bushes on infected areas will be well repaid. In this connection the experience of one garden may be quoted. For some years climatic conditions have been very unfavourable on this garden and last year the crop fell 50 per cent. below normal. It was then discovered that the garden was badly attacked by this disease. Owing to difficulties in

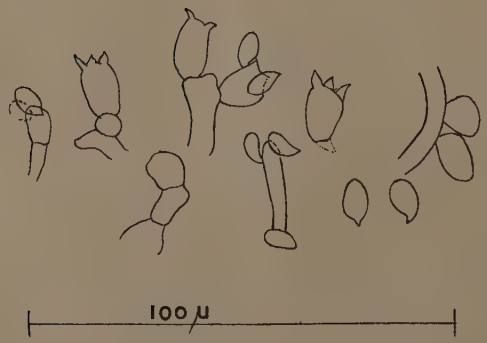
Corticium Sp 2



Corticium Sp1



BLACK-ROT



water supply it was impossible to carry out any spraying operations in the last cold weather and under these circumstances it was decided to see what could be done by taking special care in the cultivation and pruning. Under the favourable weather conditions to date the tea has responded very satisfactorily. In spite of the fact that every bush is badly attacked by the disease the bushes look remarkably well. It must not be assumed from the above that this disease can be kept in check without spraying but the loss due to the disease may be considerably reduced by attention to the general health of the bushes. The strength of the Lime-sulphur solution required is discussed later in a separate note in this journal.

THE THRIPS PEST OF TEA IN DARJEELING.

BY

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INTRODUCTORY.

"Thrips" is the popular name for a curious group of insects of which little is known, and of which much that has been recorded is probably inaccurate.

Professor Lefroy, in his "Manual of Entomology" (published 1923) summarizes the diagnostic characters of the group as follows:—"Small, elongate insects with two pairs of narrow "wings fringed with long hairs; mouth-parts piercing and suck-"ing." Even this meagre description may not be universally applicable, for in the experience of the writer the action of the thrips affecting tea, at any rate, is one of cutting, rather than piercing. One peculiarity restricted to the group, however, is the possession, in the winged forms, of two pairs of narrow fringed wings, and on this account the group is known to entomologists as the *Thysanoptera*, a word compounded from two Greek words, one meaning "a fringe," the other "a wing."

All the insects in this group are very small in size, the giants of the group being barely one-third of an inch in length, and it is therefore hardly to be wondered at that our knowledge of them is scanty.

To the average man with an interest in insects they are more particularly associated with flowers, partly on account of the fact that they are generally more conspicuous in such situations, but mainly because the average man takes more interest in flowers than in the developing leaves and leaf-buds of the plant. With the increasing study of the pests of plants, however, the species affecting other parts of the plant have come more and more into

prominence, and so long ago as 1890* Green, in his book " Insect " Pests of the Tea Plant in Ceylon," makes reference to a species of thrips which had been occasionally found to infest single tea bushes, here and there, in Ceylon. From his description it is certain that the insect he refers to is entirely different from the species which attacks tea in North-East India, so that a detailed discussion of his observations would be of little value here.

The next two references to thrips on tea were given by E. C. Cotes ; the first, in 1893, in a ' Conspectus of Indian Insect ' Pests ' in the Indian Museum Notes; the second, in 1895, in ' An ' Account of the Insects and Mites which attack the Tea Plant ' in India.' Both these references, however, were merely excerpts of Green's remarks referred to above.

The first real reference to thrips on tea in North-East India was published by Watt, in 1898, in the first edition of " The " Pests and Blights of the Tea Plant," in which he mentions the fact of having seen thrips insects on tea in Assam, though to what species his observations refer is by no means clear.

Mann, in 1903, in the second edition of the same work, refers to having also seen the insect on tea in the Duars and Cachar, but otherwise adds nothing to what was in the first edition, and indeed the details given are so scanty, and so obviously the result of casual observations, that these references cannot be taken to indicate further than that certain species of thrips had been observed on tea in Assam in 1895, and in Assam, Cachar, and the Duars between then and 1903.

So far, it will be observed, there is no record of thrips as a serious pest of tea. By 1907, however, it would appear to have attracted attention in Darjeeling, and in 1908 its attack appears to have attained serious proportions, and H. Maxwell Lefroy, then Imperial Entomologist to the Government of India, and C. B. Antram, Entomologist to the Indian Tea Association, both studied the pest to a certain extent, and published their observations in 1909, the former in " The Agricultural Journal of India "

* This date is approximate. The original is not to hand.

Vol. IV, and the latter in a pamphlet entitled : "The Thrips "Insect of Tea in Darjeeling ; investigations during season "1908," published by this Association.

Both workers found the damage done to tea in Darjeeling to be caused, in the main, by two species, one of which was commonly found, the other more rarely. Antram named these the "common thrips" and the "black thrips" respectively. Both distinguished the larval and adult stages of each of these species. Both workers, also, came to the conclusion that the pest must have been increasing gradually during the preceding few years, and both were inclined to attribute the onset of the pest to the prevalence of conditions approaching to drought. While, however, Antram was of opinion that the loss in quality caused by the insect was of even greater importance than the loss in quantity, Lefroy found that, while loss in quantity was generally admitted, planters were by no means unanimous that thrips caused loss in flavour, and that in certain cases they were definitely of the opinion that this did not occur.

Both workers inclined to the opinion that much confusion existed with regard to the effects of thrips and green fly, and both record that china and hybrid jats of bush suffered more than "good jats."

Antram stated that phenyle 1 part in water 100 parts killed the insect, but hurt the bushes if there were any sun, while Lefroy tried crude oil emulsion, soap solution, and rosin compound, and recommended the latter. Both workers, however, concluded that maintenance of the vigour of the plant must be aimed at to keep the depredations of the pest within bounds.

Antram considered that shade encouraged the pest, while Lefroy found the insect to be less abundant and destructive under shade.

A third species of thrips, confined to the flowers, and which did no harm to the plucking shoots, was described by Antram as the "yellow thrips." This species was likewise observed by both workers.

Up to this time the pest had come so little into prominence that all the species above referred to were entirely unknown even to the specialists engaged in studying the group, and it was not until 1913* that R. S. Bagnall described the yellow thrips, or, as he calls it, the tea-flower thrips, under the name of *Physothrips lefroyi*, from material received by him from Lefroy.

Lefroy had also sent him specimens of the common and black thrips, which remained unnamed, presumably from insufficiency of material, until further specimens were forwarded by the writer in 1916, after which Mr. Bagnall described the common thrips under the name of *Physothrips setiventris*,† and the black thrips under the name of *Haplothrips tenuipennis*.‡

The Insect.

As will have been gathered from the foregoing, there are two species of thrips to be found on the young shoots of the tea bush—the common thrips, *Physothrips setiventris*, and the black thrips, *Haplothrips tenuipennis*, the yellow, or tea-flower thrips, *Physothrips lefroyi*, being, so far as is yet known, confined to the flowers and of no importance from the point of view of crop.

The Common Thrips.—This insect is readily distinguished from the black thrips by not being entirely black. It is also slightly smaller. The adult forms, male and female, are readily distinguishable by the presence of the two pairs of finely fringed wings, which lie flat along the back of the elongated body when not in use, with the hairs of the fringe projecting at both sides of the body, the wings themselves appearing as a glistening band along the middle of the back.

The female, which is $\frac{1}{20}$ to $\frac{1}{16}$ of an inch long, may be distinguished by the fact that the head and thorax are golden yellow in colour, while the abdomen, or hinder half of the body, is

* Annals and Magazine of Natural History, XII, 8th series, p. 292.

† Bulletin of Entomological Research, IX, 1918, pp. 61-64.

‡ Annals and Magazine of Natural History, series 9, Vol. I, 1918, p. 210.

brownish black. The head bears, well forward on each side, a pair of large black compound eyes, while on the top of the head, between the compound eyes, are three simple eyes, red, and in certain positions looking like tiny rubies ; arranged in a triangle, with one before and two behind. Extending from between the eyes at the front of the head is a pair of jointed feelers, or antennae, which really consist of eight joints, but appear to consist of six, in fact, in examining the insect through a pocket lens they at first sight appear to consist of only five joints, as the basal joint scarcely projects beyond the head. Of these five joints, that nearest to the head is light brown, the next yellow, and the remaining three darker brown. At the hind end of the body, on the under surface, the ovipositor, or egg-laying apparatus, may be distinguished, as a narrow yellow band along the centre line.

The legs are yellow, six in number, and the front and hind pairs are thickened towards the base, the former more than the latter.

The male is smaller than the female, varying from $\frac{1}{26}$ to $\frac{1}{24}$ of an inch in length, and, except for the tip of the hind end of the abdomen, which is brownish black, is of a golden yellow colour. The large black compound eyes, however, are so distinct as to give the insect, when running about on the leaf, the appearance of being yellow, tipped with black at each end, as seen by the naked eye. The feelers, or antennae, are eight-jointed as in the female, and are similarly coloured save that the joints nearest the head are lighter, so that in this case the antennae have the appearance of being yellow on the half nearest the head, and brown on the half furthest away from the head. The prominent black compound eyes, and the three ruby-like simple eyes, are present as in the female. In the male only the forelegs are thickened, and there is of course no egg-laying apparatus.

In both sexes the mouth is situated on a cone which projects backwards, with a downward curve, at the hinder end of the under side of the head. The mouth-parts are retractible

within this cone, and appear to consist, as described by Lefroy, of one short and stout knife-shaped appendage, and a pair of more slender needles. When feeding, the insect appears to make a slit in the epidermis of the leaf, presumably with the knife-shaped appendage, and then, pushing the end of the mouth cone into the wound, sucks its nutriment from the interior tissues.

The female lays her eggs in the tissues of the leaf, using the egg-laying apparatus, or ovipositor, referred to above, for this purpose. This ovipositor consists of two pairs of horny pointed blades, with the edges serrated towards the tip, and admirably adapted for the purpose of sawing a slit in the leaf substance. When not in use they lie flat against the body, but at the time of oviposition are extended downwards at right angles, and, when embedded in the leaf, act as guides for the placing of the egg. The egg is entirely concealed within the leaf tissue, and the only external sign of its presence is a faint elevation too small to be discernible, in most cases. The egg itself is an elongated, curved, bean-shaped, translucent object, $\frac{1}{58}$ of an inch in length, and $\frac{1}{300}$ of an inch in diameter when deposited. After the young insect has emerged the egg-site is often readily distinguishable as a minute dark spot with a glistening white centre, this glistening white object being the membrane which enclosed the insect in the egg, drawn partly out of the cell by the struggles of the insect.

The eggs are placed in the buds and in the soft young leaves, generally towards the veins and ribs of the leaf, and the young insects always emerge, so far as has yet been seen, on to the upper surface of the leaf. In a rolled-up bud this surface is inside, and in the case of eggs laid in rolled-up buds the newly hatched insects emerge into the cavity inside the bud, where they live and feed happily until the bud unfolds.

Attempts were made to ascertain the length of time spent in the egg-stage, and it was found, as in the case of other species investigated by different observers, that this is very variable.

In the first case a series of shoots suspected to contain eggs were kept under observation, and the date of emergence of new-born insects recorded, with the following results :—

Shoots placed under observation.	Emergences.	Interval.
May 29	1 on June 1	3 days.
	1 ,, ,, 2	4 ,,
	5 ,, ,, 8	10 ,,
June 23	1 ,, July 1	8 ,,
	1 ,, ,, 2	9 ,,
	2 ,, ,, 8	15 ,,
	1 ,, ,, 9	16 ,,
July 14	1 ,, ,, 16	2 ,,
	1 ,, ,, 18	4 ,,

These figures show that the eggs may take as long as 16 days to hatch in June-July, but leave the shortest time undetermined. In the attempt to ascertain this males and females were paired and kept in cages on shoots which were thought not to contain eggs, and the shoots kept under observation in a similar manner, with the following results :—

Adults paired.	Emergences.	Interval.
June 23	1 on July 1	8 days.
July 7	1 ,, ,, 9	2 ,,
,, 14	1 ,, ,, 19	5 ,,
	2 ,, ,, 25	11 ,,
,, 18	1 ,, ,, 22	4 ,,
	1 ,, ,, 26	8 ,,
,, 26	1 ,, ,, 29	3 ,,
	2 ,, Aug. 2	7 ,,
,, 30	2 ,, ,, 1	2 ,,
	2 ,, ,, 5	6 ,,
Aug. 4	1 ,, ,, 7	3 ,,
,, 6	1 ,, ,, 8	4 ,,
	2 ,, ,, 8	2 ,,
	2 ,, ,, 14	8 ,,
	2 ,, ,, 16	10 ,,

From the above figures it is obvious that in most cases the shoots contained eggs before the insects were introduced. All the shoots were perforce collected from a heavily infested area, and, as has been mentioned above, it is in the majority of cases

impossible to locate the egg-site on the leaf. It seems probable, however, that 10 to 16 days is the most usual incubation period.

The newly hatched insect is colourless, translucent, about $\frac{1}{60}$ of an inch in length, with reddish-pink eyes and the fourth joint from the end of the antennae much swollen, and the end three very small. Corbett's description of the emergence of the Cotton Thrips* from its egg in the leaf of the cotton plant may be aptly applied in this case. "The young larva, on hatching, "looks like a starchy-coloured segmented worm, with red eyes and "with no indications of legs or antennae. Gradually it works it-"self out of the leaf by a slight swaying motion, and standing as it "were on its anal segment, unfolds antennae and legs. Later, "bringing its legs to the leaf surface, it pulls itself free." During the preliminary "swaying" stages the antennae adhere closely to the head, lying over against the front and under-part of the head, while the legs lie flat against the under side of the body, directed backwards, that is, since the body is in a vertical position during the emergence, downwards. The appearance of the insect at this time reminds one vividly of a "Jack-in-the-"Box" rocking at the end of the spring after the lid has been released.

The young insect hatches out in a form similar to that which it maintains throughout its larval growth, and is provided with mouth parts similar to those of the adult, which enable it to commence to feed on the tea-leaf almost immediately. It soon assumes a pale yellow colour, and increases in size until it reaches $\frac{1}{25}$ of an inch in length. In the ordinary course of events it then goes into the ground and forms a "prepupal" stage. This stage is distinguished by the shortening and swelling of the abdomen, and by the development of two pairs of wing-buds on the hinder two segments of the thorax. The prepupal is followed by a pupal stage, in which the abdomen has again elongated, the wing-buds have developed so as to reach almost half-way down the abdomen, and the antennae turn

* G. H. Corbett—"Observations on Cotton Thrips in the Gezira Blue Nile Province, Sudan, in 1918-19, Bull. Ent. Res. XI, 1920.

sharply over and lie flat on the top of the head, directed backwards. This pupal stage gives rise to the perfect insect.

It was not found practicable to observe the transformations of such a minute insect in the soil, and an endeavour was made to rear the insect to maturity in tubes. In some cases this was successfully achieved, with the following results :—

Date of emergence.	Date of attaining maturity.	Time taken.
June 1	June 16	15 days.
July 1	July 16	15 „
„ 1	„ 15	14 „
„ 8	„ 21	13 „
„ 8	„ 21	13 „
„ 16	„ 30	14 „
„ 18	Aug. 2	15 „
„ 22	„ 5	14 „
„ 25	„ 9	15 „
Aug. 1	„ 12	11 „
„ 1	„ 14	13 „
„ 2	„ 18	16 „

It is seen that the time required to attain maturity after emergence from the egg is from 11 to 16 days, 14 days being the average period. The onset of the pupal stage is marked by a change in colour of the insect to a distinctly more pronounced yellow colour two or three days before the emergence of the adult, but no moults were observed at any time, nor were cast skins observed in any of the tubes. Other observers have recorded moults at the end of the larval period, and between the pre-pupal and pupal stages, and the same moults probably occur in this case, but the phenomenon eluded observation on this occasion. From observation of the insects, however, it was concluded that as a rule one day is spent in the pre-pupal stage and two days in the pupal stage.

The above observations show that there may be considerable variation in the duration of the life cycle, the shortest period of development, from the date of deposition of the egg to the attainment of maturity, being about 18 days, and the longest period about 32 days.

This would lead one to expect a considerable over-lapping of generations, and this, in fact, occurs, and insects in all stages could be found throughout the season.

The length of life of the adult insect could not be exactly determined. In most cases the insects kept in the tubes died a few days after attaining maturity, the longest period for which they were kept alive being 10 days.

No accurate estimate of the fecundity of the insect could be arrived at. The eggs, which are comparatively large for the size of the insect, are not all fully developed at the same time, so that it was not possible to form an estimate by numbering the eggs present in the adult female. Two eggs are generally ready for deposition at about the same time, and the highest number of eggs which were found to hatch from one shoot on the same day was five, so that it appears probable that not more than half a dozen are laid per day, and that egg-laying extends over a considerable period.

The Black Thrips.—This insect is larger than the common thrips, the female attaining a length of $\frac{1}{12}$ of an inch, and the male, which is smaller, but otherwise indistinguishable from the female, having a length of $\frac{1}{16}$ of an inch. The body is entirely black, and shiny, and the glistening wings covering the front two-thirds of the back of the abdomen can generally be distinctly seen. The antennae and legs are yellow. Another characteristic is the habit of the insect of running about with the tail bent upwards, and very often it is flicked up and down rapidly, especially when the insect is excited. There is no external egg-laying apparatus in this species, which shows that the egg is not inserted into the leaf tissues. Eggs which are very probably those of this species have been found on the leaf, but none were raised to maturity, from the egg, to prove this. The attempts made to ascertain the life cycle of this insect were, in fact, all failures, for a very simple reason which did not appear until shortly before the work had to be discontinued, and there was no time to begin again. The insects were caged, and given

shoots to feed on, in a manner entirely similar to that which proved successful in the case of the common thrips, but all died for the reason that they do not feed on tea at all, but are predaceous on the common thrips.

The black thrips is therefore not an injurious insect, but a beneficial one.

The larval forms are very distinctive, and are to be found on the leaf in company with adults of the black thrips, and larval and adult stages of the common thrips. The general colour of the body is yellow, but the 1st and 3rd segments of the thorax, the 3rd and 4th segments of the abdomen, and three posterior segments of the abdomen, are crimson, so that the insect appears to be transversely banded red and yellow. The full grown larva is $\frac{1}{16}$ of an inch in length.

The larvae conceal themselves in the lichen and moss on the branches of the bush when they are ready to enter upon the pupal stages, which occupy a longer period than in the case of the common thrips, in some cases as long as 10 days.

The Effect of the Insect on the Bush.

Thrips, in Darjeeling, lives on, and attacks, the young shoots of the bush. The method of feeding, as mentioned above, appears to be to make a slit in the epidermis of the leaf, and, inserting the end of the mouth-cone into the slit, to suck the plant tissues within. This action produces a very characteristic effect on the leaf. The tissue at the edges of the slits hardens into a series of ridges which give the surface of the epidermis a roughened appearance. The wounds become discoloured, and take on a pinkish tinge, so that the surface of the leaf, after serious attack by thrips, assumes a dirty-pinkish, dry, roughened appearance. The damage is almost entirely confined to the upper surface, and is generally more intense along the edges of the leaf towards the tip, and at the base of the leaf at its junction with the leaf stalk, at both of which places there is a slight tendency for the leaf to curl upwards. This upward curl affords a certain amount of protection which is appreciated by the insects,

and this protection is increased by the action of the insects themselves. The upper epidermis, becoming dry on account of the attack of the thrips, contracts, and this causes the leaf to curl over still more, so that the insects, while attacking the leaf, are at the same time increasing the protective cover which the leaf affords.

In very severe cases this roughened, dry appearance may extend over the whole upper surface, and even below, and the whole leaf then dries up, and eventually falls off.

In the majority of instances, however, the centre of the leaf shows an appearance of tiny pinkish and black spots. The former are more or less isolated punctures which have become discoloured as mentioned above. The latter are due to the excrement of the insects. Excretion takes place in a peculiar manner. As the larva feeds a minute clean drop of fluid may be observed to begin to form on the anal extremity, which is held slightly elevated. This drop gradually increases in size, darkening through various shades of yellow and green, until it becomes a globule of considerable size (as compared with the insect). When the globules become sufficiently large they are deposited on the leaf, and darken to form the black spots to be found on the leaf surface.

The ultimate result of the action of the insect, as described above, is to render the leaf dry and brittle, and eventually, to cause it to drop off.

Another effect, however, is observable, and that is a stunting of the leaves and shoots. In extreme cases this stunting may be carried to such a length that less than one inch of new growth is made in six weeks or more, and one inch of growth may be comprised of as many as eight leaves, and a terminal bud. Instead of being soft and succulent, the young growth is tough and leathery, and not only is growth so slow that there is nothing sufficiently well-grown to pluck for two or three rounds of plucking, but such growth as is made of such a nature that it can only be collected by tearing it off with considerable force.

It may readily be seen that such a result means loss both in quantity and quality, for, though the tea made from thripped leaf may or may not show loss of flavour, etc., there can be no doubt that there must be a falling off in appearance, and that the ready comminution of the dry and brittle leaf will result in a certain percentage being removed from the higher grades.

It has been mentioned above that it is by no means uncommon to find larvae in the as yet unopened buds. Here their depredations are perforce restricted to the area of epidermis bounding the bud cavity, so that when the bud eventually opens two "sand-papery" lines, parallel to the midrib, are to be observed on the leaf. As the bud opens, moreover, the insects retreat towards the tip, which is the last part to unfold, and the result of this action is that the young leaf assumes, and retains, a concave form, with the tip of the leaf rolled up. By this time it is often so dry that an attempt to straighten it out merely results in rupture of the tissues.

An area of tea seriously affected by thrips has a brown, dried up appearance, with the plucking surface reduced to brooms of stunted, twisted, and distorted shoots, sometimes bare of leaves, and where the attack has continued over a number of years the bushes are generally stunted, distorted, leathery, and spindly.

The Habits of the Insect.

An acquaintance with the habits of an insect pest is of prime importance when the problem of control is examined, and certain of the peculiarities of this particular insect have already been touched upon.

The insect deposits its eggs entirely within the tissues of the leaf, and, as has been already stated, it is impossible, in most cases, to tell by eye where the eggs are situated. Their deposition near to the veins and ribs is probably merely due to the fact of there being a greater thickness of tissue thereabouts, but the importance of this habit of oviposition lies in the enormous degree of protection afforded to the egg stage.

On emergence the young insect takes on the normal habit of life of the species immediately, and lives more or less gregariously with the older larvae and adults on the young leaves of the bush. The insects feed mainly, as has been already observed, on the upper surface of the leaf, but they may sometimes extend to the lower surface, and occasionally attack the young shoots in the internodes between the leaves. During the day they generally shelter beneath the curled up edges and tips of the leaves, but in the evening and early morning they may be found further out in the open, and it is at this time of day that the majority of the eggs are deposited. Rain seems to interfere with them very little taking their small size into consideration, but in very heavy rain they generally remain entirely under cover.

This habit of taking shelter militates considerably against the effective treatment of the insect by means of insecticides, and a fine spray, and an insecticide with a high wetting power, are essential.

When the larva is ready to pupate it goes down into the ground, and the depth to which it goes may vary considerably, according to the depth of cultivation. The insect appears to go down to the firm soil below the depth to which effective cultivation extends. Thus, as a rule, there are comparatively few pupae in the top three inches, many more between three and six inches, and fewer, again, below that depth, though where cultivation has been deeper they are found further down. In places where the area had been trenched, for instance, pupae were found at a depth of 15 to 18 inches in the trenched lines, almost at the junction of the loose with the firm soil, and situated in the latter.

Observations were made to ascertain whether the insects pass from bush to soil, and *vice versa*, by way of the stems and branches of the bush, or whether the larvae drop from the bush, or the adults fly up from the soil.

To make these observations, strips of Tanglefoot fly paper were fastened to the stems and branches at various heights from the ground. In some cases the gummed surface was placed inwards to catch the insects, running up and down the stems, which should attempt to pass beneath the paper. In other cases the gummed surface was placed outwards to catch those which should attempt to pass over the paper, and also any adults which, flying up into the bushes, should alight on the paper.

The results of these observations were as follows :—

Tanglefoot strip fastened round the collar.

1—Gummed side in. Repeated 9 times. 1 male was found stuck to the paper in the case of the paper first attached. It was stuck near the bottom of the paper. This particular paper was not attached properly, and came loose, so that it was not a proper test of whether the insect was crawling up the stem or not. In all the other cases no insects became attached.

2—Gummed side out. Repeated 9 times. 4 males and 3 females were found to be attached to the papers at various times.

Insects were attached to the papers on 4 occasions as follows :—

1 male and 3 females, attached at the centre of the strip.

1 male, attached to the centre of the strip.

1 male, attached near the bottom of the strip.

1 male, attached at the top of the strip.

Tanglefoot strips fastened round the stems at a height above the collar of from 1 to 1½ feet.

1—Gummed side in. Repeated 7 times. No thrips became attached to any of the papers.

2— ,, ,, out. Repeated 8 times. 2 males and 3 females were found to be attached to the paper at various times.

Insects were attached to the papers on 4 occasions as follows :—

2 females, one at the centre of the strip and one at the bottom.

1 male, at the bottom of the strip.

1 female, at the centre of the strip.

1 male, at the bottom of the strip.

Tanglefoot strip fastened round the stems at from 2 to 3 feet above the collar.

1—Gummed side in. Repeated 6 times. 1 male and 2 females were found to be attached to the papers at various times.

Insects were attached to the papers on 2 occasions as follows :—

2 females attached to the lower half of of the strip.

1 male, position not recorded.

2— ,, ,, out. Repeated 8 times. 11 males and 12 females were found to be attached to the strips at various times.

Insects were attached to the papers on every occasion, as follows :—

1 female at the centre of the strip.

1 male ,, ,, ,, ,, ,, ,,

1 female ,, ,, ,, ,, ,, ,,

1 female at the top.

1 male and 1 female at the upper edge of the strip, and 2 males and 1 female at the centre.

1 male and 2 females at the centre of the strip.

4 females, 1 at the top and 3 at the bottom of the strip, and 3 males, 1 at the centre and the other two at the corner of the strip, but whether top or bottom not noted.

1 female at the centre of the strip.

2 males at the top of the strip, and 1 male at the bottom.

1 adult black thrips was also caught at the centre of one of these strips.

One noticeable feature of the above observations is that no larvae were caught. These are wingless, and must therefore either drop from the bushes direct to the soil or run down the branches and stems. Their absence from the gummed strips shows that they do not run down the stems, but fall direct to the ground. The breadth of the gummed strips was purposely made considerable, so that any insects running up or down the stems would be entangled near the lower or upper edges, and to render it practically certain that insects caught at the centre of the strips could only have got there by flight. The observations show clearly that the insects fly from the ground on to the bushes, and that a certain number may alight on the stems, and run up into the bushes.

The flight of the insect is distinctly weak, the insect propelling itself with a powerful jump, and maintaining flight for a short while only by its feeble wings. It is able to jump either backwards or forwards with equal ease. When disturbed, the insects do not take to flight until all attempts to find shelter have failed.

Neither the common thrips nor the black thrips is confined to the tea leaf (the black thrips, of course, will be found any-

where that its prey is to be found). Towards the end of the season both may be found in the flowers, and they also occur on jungle plants in the tea, on "Ruthnola" in particular.

General Observations.

The thrips insect is generally, and correctly, associated with the Darjeeling tea district, for it is in that district alone that the insect attains the status of a pest. It must not, however, be supposed that the insect is confined to the Darjeeling district. Although practically unknown as a pest in the plains, the insect flourishes there exceedingly, and is to be found on the bushes, in the Duars and the Brahmaputra valley particularly, though in the Surma Valley also, in numbers often comparable with those in which it can be found on badly thripped gardens in Darjeeling. So far as habitat is concerned, therefore, the insect may be considered to range throughout the tea districts of North-East India, both in the hills and the plains, and, from the point of development of the insect, considered alone, there is no apparent reason why it should not be a pest in the plains as well as in the hills.

Occasionally it does show up as a pest in the plains, often in conjunction with greenfly after a severe attack of red spider, and the writer has a vivid recollection of one striking instance, in Cachar, in which severe red spider had caused the bushes to shed practically all their leaves, while the miserable flush appearing on top of the bushes was stunted, distorted, and discoloured, not, as was originally thought, by greenfly, but almost entirely by thrips, the species being *Physothrips setiventris*, the Common thrips of tea.

On the tea at Tocklai Experimental Station there is generally no difficulty in finding *Physothrips setiventris*, and, although it is much more of a curiosity than a pest, one may occasionally find a twiggy shoot on which the characteristic roughened, dried up appearance of the leaf is produced, showing that in the case of extreme debilitation of the shoot, at any rate, thrips is able to produce an impression.

During the period in which the observations under record were being made the writer made two trips to the Duars and one to Tocklai, and in both places the insects could be found without difficulty, four or five or more together on a leaf as in Darjeeling, yet having no apparent effect on the outturn.

In parts of the Darjeeling area, again, conditions approximate to those in the plains, and the same forcing type of growth is obtained as is characteristic of the Duars. Such areas are seldom troubled with thrips. It is a significant fact, however, that in such cases the insects are always to be found. On one occasion, in the valley of the Rungbong, an area of such tea, waving with beautiful leaf, was pointed out to the writer as an area which never suffers from thrips. On the first leaf examined eleven of the insects were found, and the average, on the leaves examined, worked out at seven to eight per leaf. On an area near Lebong, at the same time, there was an average of four or five insects per leaf, and that area was very badly thripped.

It is recognised, as a general rule, that in Darjeeling thrips begins to affect the bushes towards the latter part of May, causing an attack which extends through June into July ; that there is then a lull, and a second attack towards the end of the season in October.

An attempt was made to ascertain whether the insect shows any tendency to fluctuation in numbers corresponding with this phenomenon. Insects were assiduously collected daily, at such time of day as the weather was favourable for collecting, and for a period of as nearly as possible two hours each day, from the middle of June to the middle of August, beyond which period it could not be continued on account of the programme laid down. The object was to ascertain whether any considerable falling off in numbers did occur at any time. The breeding records detailed above make clear that the insects kept in captivity showed no tendency to prolong their time of development in any stage as the season progressed, and the following record of insects caught in the field shows no diminution in numbers such as would be expected to presage a lifting of the attack.

Daily collection of thrips to keep a check on their numbers.

Date.	Time of day.	Common thrips.				Black thrips.	
		Males.	Females.	Young.	Total.	Adults.	Young.
June							
14	11-1	38	45	84	167	3	...
16	2·30-4	35	40	23	98	14	...
17	2·30-4	32	78	44	154	3	...
18	2·30-4	22	42	35	99	1	...
19	2·30.4	32	46	18	96	4	...
23	2·30-4	22	83	32	142	3	...
26	1-4	56	98	32	186	3	...
27	2-4	33	79	13	125	6	...
30	2-4	25	73	19	117	2	...
July							
1	1-4	52	93	18	163	2	...
2	2-4	13	42	18	73	2	...
3	1-3·30	32	58	8	98	...	...
4	1-3	43	69	6	118	1	...
5	1-3	30	63	6	99	...	...
7	2-4	22	59	7	88	1	...
8	2-4·30	43	92	7	142	3	1
9	2-4	53	72	34	159	1	1
10	2-4·30	36	64	48	148	...	...
11	2-4·30	26	47	76	149	7	...
12	2-4·15	26	34	38	98	4	3
14	2-4	8	37	78	123	2	...
15	2-3·30	9	21	27	57	2	...
16 }		Date of application of sprays					
17 }		in spraying expts.					
18	2-4	41	56	23	120	2	...
19	Raining so hard as to make collecting impossible.						
21	2-4	37	46	23	106	4	...
22	2·30-4	37	46	27	110	1	...
23	2-4	27	42	21	90	3	...
24	11-2	34	24	62	120	1	...
25	1-3	39	37	77	153	2	...
26	2-3	64	45	82	191	1	...
28	2·30-4·30	43	64	36	143	2	...
29	Date of first plucking of sprayed plots.						
30	1-3	52	54	39	145	2	...
31	11·30-1	44	47	41	132	1	...
August							
1	12·30-3	35	59	68	162	...	...
2	12·30-1	27	28	35	90	...	...
4	2-4	51	64	113	228	2	...
5	2-4	51	57	28	136	3	...
6	1-3	64	68	59	191	1	...
7	1·30-3 30	34	69	19	122	...	...
8	1-3	74	82	62	218	2	..
9	1-3-20	69	89	76	234	2	...
11	Date of second plucking of sprayed plots.						
12	1-3	75	104	11	190	3	...
13	1-3	41	59	21	121	2	...
14	11-1	52	71	12	153	...	...
15	1-3	71	93	17	181	...	...
16	1-3	93	115	17	225	...	...
18	1-3	84	111	13	208	...	...
	Total ...	1,932	2,865	1,653	6,450	93	5

It is true that during 1924, and on the area on which the insects were collected, thrips persisted on the bushes until the writer finally left in September. Yet this area looked its best, and least affected by thrips, when the writer returned from tour at the end of the first week of August, and the figures show that this was not due to diminution in number of the insects ; while the whole record, and the records of the breeding experiments, also, lead one to infer that it is by no means the habit of the insect to remain, as has been supposed, in the pupal condition in the ground from July to the end of September.

Since, then, it is not possible to correlate increased damage to the bushes with increased numbers of the insect, an examination of the other factors affecting the problem becomes necessary, and this demands some discussion of conditions obtaining in the Darjeeling district.

The tea gardens of Darjeeling are all situated in that portion of the district west of the Teesta river, an area composed of a system of ridges and spurs, with deep valleys between, thrown out, as it were, from the higher mountains to the north-west. The area is entirely a mountain region, and the hills composing it rise abruptly from the plain of the Terai, which forms the southern boundary of the area, the northern boundary being the valley of the Great Rangit river, the eastern boundary the valley of the Teesta, and the western boundary the hills of the Singalila range to the north and the valley of the Mechi river to the south. The Singalila range throws out a ridge, at an elevation of 7,000 to 8,000 feet which, lying in an east and westerly direction, extends from Simana-basti on the west to Ghum on the east. To the north of this ridge the land descends to the Great Rangit. To the south of the ridge the land descends to the plains. From near Ghoom three other hill ranges radiate. To the south, the Senchal-Mahaldiram ridge extends towards Kurseong, at an elevation of from about 8,000 feet towards Ghoom to 7,000 feet at the south, where it forks, one spur passing west of south, the other south-east and then east. Between the spurs forming this fork is the valley of the Mahanadi river,

opening on to the plains to the south. To the west of the main Senchal-Mahaldiram ridge is the valley of the Balasun, also opening to the plains to the south, and bounded, still further west, by a ridge passing south from the Singalila range, on the other side of which is the Mechi river. Smaller spurs thrown off by the Simana-Ghoom range and the Senchal-Mahaldiram range, delimit the tributary valleys of the Balasun—the Rungbong valley, the Nagri valley, the Sonada valley, etc.

From the main Senchal ridge another range, the Tukdah range, branches off, a little east of Ghum, and takes a north-easterly direction to the junction of the Great Rangit and Teesta rivers, ranging in elevation from over 7,000 feet near Ghum to less than 1,000 feet to the north-east. Subsidiary spurs from this range and the Senchal-Mahaldiram range divide the area between into the valleys of the Rangu, Rangjo, and Reaing rivers, all of which flow east into the Teesta river, the valley of which is a gorge passing almost directly north and south to open on the plain of the Terai.

A further range, the Darjeeling-Jalapahar range, extends northward from Ghum at an elevation of between 7,000 and 8,000 feet to Darjeeling, where it forks and gives off two spurs, the Lebong spur and the Tukvar spur. Between this range and the Tukdah range lies the valley of the Rangnu river, and to the west, between the Darjeeling range and the spurs of the Singalila ridge, the valley of the Little Rangit, both rivers flowing in a north-easterly direction into the Great Rangit.

The whole area may thus be regarded as composed of seven narrow river-valleys, radiating from a watershed in the centre of the district. Opening to the south are the valleys of the Balasun and Mahanadi ; opening eastward are the valleys of the Rangu, Rangjo, and Reaing ; opening to the north-east are the valleys of the Rangu and the little Rangit.

Thus, speaking generally, elevations decrease in all directions from the centre of the district, the valleys widen, and the

hill slopes become less precipitous. The elevation of the centre of the district is, for the most part, round about 7,000 feet rising to 8,000 in places. At the boundaries on the north, east, and south the elevation is below 1,000 feet above sea level. Most of the tea in the district ranges from the lowest elevation to about 6,000 feet, though a little extends beyond it. Conditions at the lower elevations are subtropical ; at higher elevations temperate.* Between these two extremes there are all gradations, modified, in places at the same elevation, according to their situation in the district.

Thus, one estate may be on the windward side of the watershed, another in the lee of it ; or one may be on the sunny side of the valley, another on the shaded side ; and so on. These variations are so extensive and complex, however, that attempts to correlate such data as could be obtained, in the time available, with regard to them, merely serve to obscure the issue.

It seems well, therefore, in the present stage of the enquiry, to attempt nothing beyond a correlation between conditions in general and the distribution of the pest in general.

The moisture-laden winds prevalent in the monsoon enter the district from the south. It therefore follows that the valleys of the Balasun and Mahanadi, which open to the south, are fully exposed to them, whereas the winds, before reaching the valleys of the Rangjo and the Rangu, have been checked to a certain degree by the intervening ranges, and lost a good deal of their moisture, while after passing over the main watershed to enter the valleys of the Rangu and the Little Rangit they have lost even more. This is shown distinctly by the rainfall figures. For instance, the average rainfall, for 37 years, at Kurseong, situated in an exposed situation on the Senchal-Mahaldiram range, is 161.26 inches ; the average rainfall, for 41 years, at Gielle in the Rangu valley, is 117.3 inches ; while the average rainfall at Ging, in the Rangnu valley, for 18 years, is 84.05

*The mean temperature of Darjeeling is only two degrees above that of London.

inches.* These differences might possibly be intensified were it not for the fact that part of the monsoon wind also reaches the Rangu and Rangnu valleys by way of the Teesta gorge.

The main result of this movement of the monsoon wind is, that while in the valleys opening south the rainfall tends if anything to increase in passing down the valley, in those valleys opening to the north-east and east the tendency is for the rainfall to decrease towards the mouth of the valley. Any modification due to increased rainfall may therefore be expected to extend further down the valley in the case of, say, the Balasun valley, than in the case of the Rangnu valley,* and it is significant that the action of the thrips on the tea-bushes is in most instances more intense at the lower elevations in the Balasun valley than is the case at equal elevations in the Rangnu valley.

At higher elevations, however, this is not the case. At an elevation of between 4,000 and 4,500 feet there is a distinct mist-line, above which mist might almost be said to be the rule during the monsoon season.

Several changes are noticeable at about this level. There is, naturally, a change in humidity. There is also a distinct change in temperature. There is a change in the appearance of the tea ; growth is slow, and the stems and branches, which certainly bear mosses and lichens at lower elevations, now become festooned with them. There is also a change in the character of the jungle, and above this elevation *ruthnola* becomes more in evidence, replacing the grasses which have competed with it successfully lower down. Accompanying all these changes is a slower power of recovery, on the part of the bush,

*The head of the Rangnu valley, to reach which the monsoon winds have first to pass over the Ghoom Jalapahar range, affords an excellent example of the effect of situation on rainfall. Mineral Spring is on the lee-side of the valley, directly beneath the crest of the range. The air passing over the ridge expands and descends on entering the valley, and is compressed and deflected upwards again on striking the Lebong spur on the other side of the river. In consequence, it is found that the average rainfall at Mineral Spring, for the five years, 1919 to 1923, was only 78.8 inches, while at Bannockburn, directly opposite, the average for the same period was 86.3. Beyond Bannockburn, to the north and further away from the Ghoom ridge, the rainfall gradually decreases, and at Ging the average for the same period is 77.8 inches.

from thrips attack. There is no sharp line of demarcation, indeed the mist-level fluctuates throughout the season, and at different places ; but, while the changes are gradual, it is distinctly noticeable, at or near 4,500 feet, that conditions approximate to those of higher elevations, while at or near 4,000 feet they tend more towards the conditions at lower elevations. Moreover, while there is always a sharp change in temperature and humidity when mist is prevalent, a rapid change in temperature may often be experienced when the weather is clear.

Thus, it cannot be lost sight of that elevation, and situation as regards temperature, humidity, and rainfall, have a distinct bearing on the matter, the combination of low temperature with high humidity and rainfall tending to bring about a condition of affairs which tends towards more intense damage by thrips.

Another factor which appears to affect the distribution of the insect is the variety of plant. It is the common belief among the planters that indigenous *jats* of tea suffer less from the depredations of thrips than China *jats,* and whereas, at higher elevations especially, indigenous tea is found to be badly attacked, it yet appears to offer greater resistance to the attack, and to recover more rapidly.

Planting opinion is not altogether unanimous with regard to the effect of shade, though the writer came across more instances of shade having proved beneficial than the reverse, and the removal of shade on account of blister has on more than one occasion resulted in thrips showing up on the tea. It is distinctly noticeable, however, that while blister and thrips are by no means incompatibles, the rapid, succulent growth characteristic of cut-back tea, and so eminently favoured by blister, is a type of growth on which thrips does not make headway. Tea under shade, as a rule, especially under heavy shade, tends to produce a smaller number of more quickly growing shoots, so that as regards thrips the effect of shade may logically be regarded as apt to check the insect rather than encourage it.

Examination of a representative collection of analytical data has thrown no light on any soil peculiarities, shown by the usual method of analysis, which can be correlated with thrips. Yet instances were noticed, in the field, in which differences in the degree of attack by thrips could hardly be accounted for on any other hypothesis than that of some difference in soil conditions.

In one case, in particular, on Mineral Spring, in the Rangnu valley, where a small *jhora* flowed through a section of tea, the bushes on one side of the *jhora* were found to be badly affected, whereas those on the other side were scarcely attacked. This, the writer was informed, is invariably the case on that section. The bushes were of the same age and *jat*, the elevation the same, the soil apparently uniform, and the two areas so close together that it was difficult to see in what way the soil could differ. At the same time, the jungle growing amongst the tea on the two sides of the *jhora* was entirely different. On the side affected by thrips the soil was covered almost entirely by *dhub* grass, while on the other side there was complete absence of this grass, and its place was taken by the coarse grass which as a rule replaces ruthnola at about 4,000 feet and below. The soil, on the side unaffected by thrips, was loamy and friable to the feel, while that on the side badly affected was sticky, damp, and cold to the touch. On examination of the soils it was found that the acidity was higher in the latter case than in the former.*

In a second instance,† also on Mineral Spring, in which, in the case of two areas on the same slope, one a little above the other, the tea on the upper area, at the time, was scarcely attacked, while that on the area below was badly affected, it

*The figures obtained, using the B. D. H. Universal Indicator were—

Soil from area with thrips, pH 7.0
" " " " no thrips, pH 7.5.

A test with potassium thiocyanate gave a much deeper colour in the case of the latter soil than the former.

†In this case the figures obtained by the B. D. H. Universal Indicator were—

Free ... ... pH 8.0
Bad ... ... pH 7.0

Potassium thiocyanate gave the same results as before.

was again found that the degree of acidity of the soil on the affected area was higher than that of the soil on the unaffected area. In this case both areas are generally badly affected, and there was no apparent reason, beyond this difference in acidity, why this should not have been the case at the time.

Cases of this nature, however, were the exception rather than the rule, and the evidence afforded is to some extent discounted by an instance at Lebong, which one was able to examine in more detail, in which, of two neighbouring bushes, one was very badly thripped, while the other, though the insects were feeding on it in numbers, was hardly affected. Both bushes appeared to be of China *jat*, but one was growing much more vigorously than the other, with larger leaves, better wood and a much stronger flush, and this state of affairs continued in spite of the continual presence of the insects. Samples of soil were examined from round the roots of both bushes, but with negative results, all showing the same acidity, or rather lack of it, for the soil was neutral in reaction, if not indeed alkaline.* There were, however, stones beneath the affected bush, while the other was deeper rooted. Pieces of the roots, and shoots and young leaves of the bushes, were then carefully washed with distilled water, sectioned, and tested with indicator for acidity. The results were in agreement in every case, and indicated that in both cases the acidity of the root was higher than that of the shoots and leaves, while the roots, shoots, and leaves of the unaffected bush showed a higher acidity than those of the affected bush.† No other instance such as this was observed.

Other samples were taken, at various places, in which difference in behaviour towards thrips, at two places, was to be observed, but in all these cases differences in type of soil, elevation, *jat* of bush, shade, and so on, could not be eliminated in

*The figure obtained with the B. D. H. Universal Indicator was pH 8.0. Recent work in the Chemical Laboratory has shown that the figures given by the Universal Indicator are generally too high, and on the results there obtained this figure would correspond roughly with the pH 7.0, which is practically neutrality. With potassium thiocyanate there was no trace of any pink colour.

†The figures, again using the B D. H. Universal Indicator were :—

Affected.	*Free.*
Roots pH 5.5	Roots pH 4.0 to 5.0
Shoots and leaves, pH 7.0 to 7.5	Shoots and leaves pH 6.5 to 7.0

the same way. It is curious to observe, however, that at Tukdah, on the same side of the Rangnu valley as Mineral Spring, the soil from the worst affected spot was more acid,* while at Bannockburn‡ and Ging† on the same side of the Rangnu valley as Lebong, the soil from the worst affected spot was less acid. In the Teesta§ valley no differences in the degree of acidity, between plots affected in varying degree, could be found.

It is to be regretted that time and conditions did not allow of a more extensive enquiry into this aspect of the question, for, while the observations outlined above are conflicting and unsatisfactory, they do appear to indicate the existence of local variations between one spot and another, and it is at any rate curious that amongst the few scattered records those from places which are similarly situated should be similar in kind. There can be no doubt, however, that apart from these local variations soil conditions play an important part owing to impoverishment and loss of soil caused by wash.

The question of drainage, in Darjeeling, appears to be intimately bound up with that of wash. Save in a few instances, the tea is situated on slopes so steep that the consideration of wash becomes all-important from the point of view of vigour of the bush, quite apart from thrips. Here, again, however, as has been shown above, thrips is found to be less virulent, other things being equal, on the more vigorous bushes. It was noticeable, when the rains first begun, that there was very little wash, the rain which fell sinking into the dry soil with some rapidity. At the end of a week or so, however, the slightest shower was

*Badly affected ... pH 6.5
Less ,, ... pH 7.5
‡Badly affected ... pH 7.0
Less ,, ... pH 6.5
†Badly affected ... pH 7.0
Less affected ... pH 7.5
§Rungli Rungliot—three areas affected in varying degree all pH 6.5
Gielle—slightly affected ... ... pH 7.0
badly ,, ... pH 7.0
Teesta—moderately bad ... ... pH 7.0
Namring—moderately bad ... pH 7.0
very good tea ... ... pH 7.0

accompanied by copious running water, the slopes being so steep that only a negligible quantity soaked into the soil. Light rain, too, produced runnels of sufficient velocity to carry away the coarser as well as the finer particles of the soil, so that the bulk of the wash experienced is not a case of the washing out of the finer particles, as in the plains, but results in the carrying away of the soil as a whole. Thus, in hollows where the velocity of the wash-water is checked, and the coarser particles deposited, the soil is often considerably more sandy than that on the slopes above. It was noticeable, that even hand-weeding round the bushes during the rains is productive of a considerable amount of wash, and the drip from the bushes was seen to be sufficient to wash the soil away from round the surface roots, many of which, after hand-weeding, were often left high and dry in the air. Owing to the shallow depth of soil in most places the majority of the feeding roots of the bushes are near the surface, and such a state of affairs must result, as indeed it does, in loss of vigour in the bushes by constant exposure and death of a certain proportion of the feeding roots. Not only so, but many of the roots are so near the surface as to be pulled out of the soil along with the roots of the grasses, so that they are left high and dry quite apart from the question of wash. Such a state of affairs must be a constant drain on the vigour of the plants, with a resulting decrease in the rate of growth, and, in consequence, an increase in the effect of thrips.

In "thullying" round the bushes, also, this exposure of roots occurs in the same way, especially when the type of fork used is that with the prongs bent so that it can be used in a manner similar to a rake, for with this implement the coolies drag the jungle, and, with the roots of the latter, the soil, away from the collar of the bush. For this reason a straight fork would be preferable, and, if a straight fork be used, "thullying" would be preferable to hand weeding. By this the soil is loosened to a greater depth, and it thus interferes to a certain extent with the thrips when in the soil, indeed the writer met more than one planter who was of opinion that thullying had been

of distinct benefit with regard to thrips. This deeper cultivation, moreover, would help to check wash, for it is a matter of common experience that wash is greater the more shallow the depth of cultivation. Lastly, the action of the straight fork is to throw the soil up round the surface roots rather than to drag it off them. Carried out in this way, the maximum of benefit and the minimum of harm should accrue, not only as regards thrips, but also as regards the vigour of the bush itself, and if with this be combined such suitable methods of checking wash in general as have been, from time to time, recommended by this department, damage due to thrips from this cause should be reduced to a minimum.

It was not possible to trace any closer connection between thrips and subsoil drainage. The main problem, so far as thrips is concerned, would appear to lie in the control of wash.

Mention of the effect of "thullying" suggests that cultivation may be not without its effect on thrips, and this is indeed the case. It was mentioned above, in discussing the habits of the insect, that it goes down to firm soil to pupate, and that the greater the depth of the loose, cultivated, surface layer, the greater the depth to which it goes. It is obvious that the further down the insect has to go, and the further it has to come back again, the greater is the risk of it failing to make the journey safely. Darjeeling soils are of a type that tends to pack somewhat quickly, so that even in the cultivated layer, unless the soil can be turned over fairly often, compacted portions of soil will quickly form, which would afford suitable lodgment to the pupa. Everything therefore points to the desirability of a good deep digging, and of frequently turning over the surface layer. This at once brings one up against the question of wash, on account of which, in many places, cultivation is reduced to a minimum, and at first sight it would hardly appear possible to have it both ways. However, it is possible to give a good deep digging in the cold dry weather, when wash is at its minimum, and with proper precautions against wash a fair amount of

thullying may be done at other times. The matter hinges, of course, on labour, for whatever happens wash must be avoided.

Manuring has been carried out with success in many parts of Darjeeling, and outturn has been raised on gardens affected by thrips, more especially at medium elevations. Any scheme of manuring productive of more rapid growth and greater vigour in the bushes as a whole has its corresponding effect in forcing the bushes through attack by thrips, but this effect decreases with increase in the elevation and a corresponding drop in the mean temperature. At high elevations with slower growth and lower initial outturn, a corresponding percentage increase is a lower actual increase, so that the differences are not so marked, yet even at the highest elevations vigorous, healthy bushes show a much greater degree of resistance to thrips attack. The best results appear to have accrued where a complete manure has been applied, but there is no evidence as yet to enable one to suggest any special scheme of manuring for thrips.

The system of pruning and plucking generally adopted in Darjeeling is one which will tend to assist the insects to obtain a hold on the bushes. Unpruned and skiffed tea, even in the plains, tends to give very small leaf, and to close up fairly early in the season. In the hills this tendency is emphasized, and a system in which the tea is left unpruned or skiffed for three or four years in succession emphasizes it still further. On the other hand, growth is so slow that if the bush were to be treated so that it had to make new wood every year there would be a considerable loss in crop, which might even exceed the toll taken by thrips. It is therefore hardly feasible to alter the system, and increase of the vigour of the bushes by judicious cultivation and manuring, so far as may be done without loss in quality, is the only avenue left open.

Experiments with Insecticides.

The use of phenyle and rosin wash against thrips has long been discontinued—indeed, insecticides have been developed

to such an extent since the days when they were recommended that their trial would now hardly be thought of.

In 1916 the writer was able to devote about three weeks to the study of thrips, and then made a small trial with insecticides, available at that time, which appeared to afford indications that insecticides might be of distinct value against thrips. The insecticides used in this trial, with the results obtained, are given below :—

Treatment.	Increase over check in weight of leaf obtained.	Percentage of damaged shoots.
Check	.....	50%
X. E. X. Green*	78%	5%
Lime-Sulphur	39%	8%
Cook's Nicotine Spray	28%	12%
Katakilla	18%	8%
Crude oil emulson	12%	19%

In these experiments there was no preliminary weighment to ascertain the yield and percentage of damaged shoots in the various plots before treatment, nor was any observation made on the number of insects actually killed in each case. In spite of this fact, however, one might be justified, from the high outturn and low percentage of damaged shoots, in believing that X. E. X. Green had been of distinct value.

*X. E. X. Green was used at a strength of 3 per cent., as recommended by the makers.

Cook's Nicotine Spray was used at a strength of " one tea-spoon to two quarts of water " as recommended by the makers.

Katakilla was used at a strength of ¼ lb. to 5 gallons of water, as recommended by the makers.

Lime-sulphur was used at a strength of 1 part of stock solution (made up as recommended in " Notes on the Spraying of Tea ") to 10 parts of water.

Crude oil emulsion was that made by Messrs. Bathgate & Co., Calcutta, to Lefroy's formula, at a strength of 1 part to 96 parts water.

In 1924, however, more elaborate experiments were carried out on a larger scale.

Several insecticides of recent introduction on the market were received for trial, and these were tried in comparison with X. E. X. Green as being the most effective of the substances tried previously. The insecticides tried were :—Insectox—a product of Heppell's Laboratories, London, obtained from Messrs. McLeod & Co., Calcutta, an insecticide of such efficiency that we use it regularly, with unfailing success, for killing wasps in the tea bushes.

Empranin—an insecticide sent for trial by Messrs. The Planters' Stores & Agency Co., Ld., Calcutta.

Clensel—sent for trial by J. F. Cameron & Co., Mercantile Buildings, Calcutta.

N. Q. Wash—a nicotine—quassia wash marketed by Messrs. William Cooper & Nephews, Berkhamsted, England, one of the standard insecticides for use against thrips in England.

Belumnite—one of the latest " powder sprays " requiring no water and convenient for that reason, being blown into the bushes as a powder, marketed by Messrs. Cooper and Nephews.

X. E. X. Green was obtained from Messrs. Allen Bros. & Co., Calcutta.

All the insecticides, except of course the powder spray, were used at strengths of 3 per cent., 5 per cent. and 10 per cent. in water. All were convenient to use, and mixed readily and well.

Their killing power on the insect was first tested in the temporary laboratory by allowing a drop of the insecticide to fall on to the insect, resting on a piece of blotting paper to absorb the excess insecticide, and noting the time taken to kill the insects.

The results of these tests were as follows :—

Insecticide.	Strength.	Results.
Insectox.	3 % sol. in water.	Males killed in from 50 to 70 seconds. One specimen lived for 1½ minutes.
		Females killed in from 40 to 100 seconds.
		Larvae killed in 10 to 20 seconds.
,,	5 % sol. in water.	Males killed in from 40 to 60 seconds. One specimen died in 15 seconds.
		Females killed in 50 to 60 seconds. One specimen died in 35 seconds.
		Larvae killed in 5 to 10 seconds.
,,	10 % sol. in water.	Males killed in 18 to 25 seconds.
		Females killed in 15 to 30 seconds.
		Larvae killed in 2 to 5 seconds.
Empranin.	3 % sol. in water.	Males killed in 50 to 90 seconds.
		Females killed in 45 seconds to 2 minutes.
		Larvae killed in 10 to 15 seconds. One individual lived for 1 minute.
,,	5 % sol. in water.	Males killed in 20 to 30 seconds.
		Females killed in 20 to 30 seconds.
		Larvae killed in 5 to 8 seconds.
,,	10 % sol. in water.	Males killed in 15 to 20 seconds. One individual died in 5 seconds.
		Females killed in 10 to 20 seconds.
		Larvae killed in 2 to 5 seconds.

Insecticide.	Strength.	Results.
XEX—Green.	3 % sol. in water	Males killed in 15 to 30 seconds.
		Females killed in 20 to 45 seconds.
		Larvae killed in 10 to 15 seconds.
,,	5 % sol. in water.	Males killed in 15 to 20 seconds.
		Females killed in 15 to 50 seconds.
		Larvae killed in 5 to 10 seconds.
,,	10 % sol. in water.	Males killed in 10 to 20 seconds. One specimen lived for 35 seconds.
		Females killed in 15 to 30 seconds.
		Larvae killed in from 1 to 5 seconds.
N. Q. Wash.	3 % sol. in water.	Males killed in from 20 to 30 seconds.
		Females killed in 20 to 40 seconds.
		Larvae killed in 5 to 10 seconds.
,,	5 % sol. in water.	Males killed in 15 to 20 seconds.
		Females killed in 15 to 25 seconds. One specimen died in 10 seconds.
		Larvae killed in 2 to 5 seconds.
,,	10 % sol. in water.	Males killed in 15 to 25 seconds.
		Females killed in 15 to 25 seconds.
		Larvae killed in 2 to 5 seconds.

Insecticide.	Strength.	Results.
Clensel	3 % sol. in water.	Males killed in 50 to 90 seconds.
		Females killed in 40 to 90 seconds.
		Larvae killed in 15 to 20 seconds.
,,	5 % sol. in water.	Males killed in 35 to 45 seconds.
		Females killed in 25 to 45 seconds. One specimen lived for 60 seconds.
		Larvae killed in 10 to 15 seconds. One specimen lived for 25 seconds.
,,	10 % sol. in water.	Males killed in 15 to 25 seconds. One specimen lived for 40 seconds.
		Females killed in 20 to 40 seconds. One specimen lived for 60 seconds.
		Larvae killed in 5 to 10 seconds.
Belumnite.	Powder spray.	Males killed in 1 to 2 minutes. One specimen lived for 2½ minutes.
		Females killed in 1½ to 2 minutes.
		Larvae killed in 15 to 20 seconds.

It will be observed that all the insecticides killed the insects in both larval and adult stages, and that the stronger solutions killed more quickly, as would indeed be expected. Moreover, insects in the larval stage were killed more quickly than the adults, and the males died more readily than the females. On the whole, X. E. X. Green and N. Q. Wash were about equal in killing power, and slightly more efficient than the rest, while there was also little to choose between Insectox, Empranin,

and Clensel, though all were slighly less efficient than the two former. Belumnite, the powder spray, killed much more slowly than any of the rest.

The experiments were carried out on an area of very old China tea very badly affected by thrips. The plots were plucked at the time the leaf was ready, and the weight of leaf, the average number of shoots per bush, and percentage intensity of infection ascertained before the application of any insecticide. The insecticides were applied the day after plucking, and the percentage of insects killed ascertained by direct count of insects, dead and alive, on the leaves. At the next round of plucking, and the round after that, the weight, number of shoots per bush, and percentage intensity of infection were ascertained as before. In estimating the latter the plucked shoots were divided into three classes, according to the degree of damage done by thrips. These classes were—undamaged, slightly affected, badly affected. The percentage of each class was calculated, and multiplied by the numbers 0, 1, and 2, respectively, and the percentage intensity of infection was then half the total figure thus obtained.*

The following table gives the percentage of insects found to have been killed by the various insecticides in the field.

Treatment.	Percentage of insects killed.
Insectox, 3%	6·7
,, 5%	85·7
,, 10%	100·0
Clensel, 3%	8·3
,, 5%	46·7
,, 10%	66·7
Empraain, 3%	44·4
,, 5%	60·0
,, 10%	81·25
X. E. X. 3%	81·8
,, 5%	75·0
,, 10%	88·2
N. Q. Wash, 3%	64·3
,, 5%	100·0
,, 10%	88·9
Belumnite	13·0

*For full details of this method of estimating damage done by an insect pest see "Factors Affecting the Control of the Tea Mosquito Bug."

These figures afford indisputable proof that the insecticides killed the insects in the field as well as under laboratory conditions. The powder spray is again found to occupy a lower position in the scale of efficiency, while the behaviour of the other insecticides was not entirely regular. This is a matter of common experience in experiments with insecticides in tea, and is due, mainly, to the difficulty of obtaining even application, though doubtless the errors in observation are not inconsiderable. However, the figures do definitely show that all the insecticides used will kill the insects in the field if they can be properly applied.

The figures for the weight of leaf obtained are as follows :—

Treatment.	Weight of leaf in ounces per bush.			
	Before treatment.	After treatment.		
		July 29.	August 11.	Total.
Check (average)	0·8	0·7	0·5	1·2
Insectox, 3%	1·2	0·8	1·2	2.0
,, 5%	1·2	0·8	0·8	1·6
,, 10%	0·8	0·8	1·2	2·0
Clensel, 3%	1·2	1·2	0·8	2·0
,, 5%	1·2	0·8	0·8	1·6
,, 10%	0·8	0·8	0·4	1·2
Empranin, 3%	0·4	0·8	1·2	2·0
,, 5%	1·2	0·8	0·4	1·2
,, 10%	1·2	0·8	0·8	1·6
X.E.X. Green, 3%	0·4	0·4	0·4	0·8
,, 5%	0·8	0·4	0·8	1·2
,, 10%	0·4	0·4	0·4	0·8
N.Q. Wash, 3%	0·8	0·4	0·8	1·2
,, 5%	0·4	0·4	0·8	1·2
,, 10%	0·8	0·8	0·8	1·6
Belumnite	0·8	0·8	0·4	1·2

It will be seen that the yields of the plots were irregular to begin with. On subtracting the yield before treatment from the yield after treatment, and comparing the differences obtained

with that on the check plots, however, it is found that only seven of the plots gave an increase over the check, these being :—

Treatment.	Increase over check in yield in ounces per bush.
Insectox, 3%	0·4
,, 10%	0·8
Clensel, 3%	0·4
Empranin, 3%	1·2
N. Q. Wash, 5%	0·4
,, 10%	0·4
Belumnite, ...	0·4

Comparison of these results with the percentage of insects killed on the various plots shows clearly that the weight of leaf obtained after treatment bears no relationship with the percentage of insects killed.

The number of shoots obtained per bush was as follows :—

Treatment.	Number of shoots per bush.			
	Before treatment.	After treatment.		
	July 15.	July 29.	August 11.	Total.
Check (Average)	92	54	61	115
Insectox, 3%	100	56	86	142
,, 5%	100	54	78	132
,, 10%	96	64	105	169
Clensel, 3%	100	78	89	167
,, 5%	100	77	71	148
,, 10%	100	57	37	94
Empranin, 3%	43	70	83	153
,, 5%	90	66	56	122
,, 10%	100	79	68	147
X. E. X. Green, 3%	100	54	49	103
,, 5%	92	36	58	94
,, 10%	36	39	58	97
N. Q. Wash, 3%	100	39	46	85
,, 5%	80	42	75	117
,, 10%	68	51	41	92
Belumnite	100	43	55	98

Examination of these figures shows that eleven of the plots show increases, as compared with the check plots, varying between 1 and 87 shoots per bush, while on five of the treated plots there is a decrease. No relationship can be traced, however, with the percentage of the insects killed. Indeed, on the N. Q. Wash 10 per cent. plot, on which 98 per cent. of the insects were killed, there is an increase of only 1 shoot per bush, while on the Empranin 3 per cent. plot, on which only 44 per cent. of the insects were killed, there is an increase of 87 shoots per bush. Similarly with other plots ; a result which can only be regarded as entirely independent of the number of insects killed.

The percentage intensity of infection, as judged by the damage done to the leaf, is a matter which might naturally be expected to show a definite relationship to the percentage of insects.

The figures obtained are as follows :—

Treatment.		Percentage Intensity of Infeciton.		
		Before Treatment.	After Treatment.	
		July 15.	July 29.	August 11.
Insectox,	3% ...	48·2	26·9	3·0
,,	5% ...	46·4	15·4	4·4
,,	10% ...	63·7	28·3	5·0
Clensel,	3% ...	38·2	35·5	4·7
,,	5% ...	54·5	35·2	11·3
,,	10% ...	36·0	30·1	16·0
Empranin,	3% ...	62·5	16·0	3·2
,,	5% ...	36·7	6·5	2·4
,,	10% ...	48·7	28·1	3·3
X. E. X. Green,	3% ...	40·6	30·1	5·9
,,	5% ...	30·4	27·7	3·3
,,	10% ...	66·3	20·5	2·4
N. Q. Wash,	3% ...	41·6	17·8	5·8
,,	5% ...	51·8	26·9	2·3
,,	10% ...	47·6	19·8	3·5
Belumnite	... ...	32·0	28·5	3·6

It will be seen that the percentage intensity of attack in plots, before spraying, varied from 32 per cent. to 64 per cent. ; also that all plots showed improvement at the end of the first fortnight, and still further improvement by the end of another fortnight. This improvement was observable in the check plots as well as in the treated plots, and is evidence of the seasonal improvement which is generally admitted to take place at about this time of year.

In this connection reference may be made to the daily collections of thrips on the area recorded earlier in this paper, from which it will be seen that this general improvement was not accompanied by any diminution in the number of the insects in general. This confirms the opinion already expressed that the condition of the bushes is mainly responsible for the state of affairs, and moreover, this is confirmed by an examination of the figures for weight of leaf per bush and number of shoots per bush obtained. Neither of these figures, of themselves, can be expected to show much relationship, for no two of the bushes were in the same state of flushing at the same time. When, however, the weights of the individual shoots over all the plots are calculated, it is found that the weight per individual shoot, on the three dates on which the bushes were plucked for the experiment, worked out as follows :

July 15th—0.0107 ounces.
,, 29th—0.0135 ,,
Aug. 11th—0.0122 ,,

Taking the weight on July 15th as 100, to obtain percentages, the figures become :

July 15th—100
,, 29th—126
Aug. 11th—114

This signifies percentage increases in weight of the shoots of 26 and 14, figures which indicate beyond doubt that the bushes had in some way increased in vigour, temporarily at any rate.

Since the original intensity of infection varied throughout the plots, it is apparent that the final intensity would vary on this account, but this can be got over by calculating the later intensities in percentages of the original. When this is done, and allowance made for the decrease shown by the check plots, we obtained the following figures :—

Treatment.	Percentage of insects killed.	Differences in percentage intensity from check.	
		At first plucking.	At second plucking.
Insectox, 3%	6·7	−19	−15
,, 5%	85·7	−42	−11·5
,, 10%	100·0	−30·5	−13
Clensel, 3%	8·3	+18	− 8·5
,, 5%	46.7	−10	0·0
,, 10%	66·7	+ 8·5	+23.5
Empranin, 3%	44·4	−49·5	−16
,, 5%	60·0	−57·5	−14·5
,, 10%	81·25	−17	−14
X.E.X. Green, 3%	81·8	− 1	− 6
,, 5%	75·0	+16	−10
,, 10%	88·2	−44	−17·5
N.Q. Wash, 3%	64·3	−32	− 7
,, 5%	100·0	−23	−16·5
,, 10%	88·9	−33·5	−13·5
Belunnite	13·0	+45	+16·5

Yet again it will be seen that the results bear little or no relation to the number of insects killed.

Thus, while all the insecticides tried killed the insect, not only under laboratory conditions, but in significant numbers in the field, and it must therefore be admitted that the insects can be killed by means of spraying, yet it does not necessarily follow that the death of the insects will be succeeded by a proportionate increase in the amount of leaf, and decrease in the amount of damaged leaf. It is therefore apparent that in the absence of other measures for assisting the bushes to throw off an attack, spraying alone, though it may kill the insects, will not make the bushes grow, and unless this is to occur it is difficult to see that one is much better off.

The conclusion which must be drawn, therefore, is that spraying will kill the insects, if the vigour of the bushes can be

increased sufficiently for them to take advantage of it, and that the logical method of setting to work is to take measures to improve the condition of the bushes first, and, when these measures are seen to be resulting in improvement, to invoke the assistance of insecticides.

Conclusion.

Thrips is not confined to the Darjeeling District, but is to be found also in the plains, where it occasionally comes to the fore on bushes, or parts of bushes, which have declined in vigour, and are making poor and slow growth, from any cause.

In Darjeeling there is a tendency to slower and poorer growth, a tendency which increases as the elevation increases and temperature falls. This tendency is emphasized by impoverishment of the bushes by wash, by the difficulty of carrying out adequate and proper cultivation without increasing wash, and by the system of pruning only occasionally, and leaving the bushes unpruned and skiffed for a number of years, which obtains in the district.

In regions above the mist-line this tendency proceeds so far that thrips is practically universal.

The periods of maximum attack, in the early part, and towards the end, of the season, are not due to seasonal variation in the numbers of the insects. That being so, it can only be concluded that the condition of the bushes must have something to do with it.

It is at any rate significant that the period of minimum damage by thrips corresponds with the period when yield is at its maximum, not only where thrips is prevalent, but in districts where thrips is unknown as a pest.

This fact provides additional evidence that lack of vigour in the bushes is a primary cause of damage by thrips, and the fact that the individual shoots show increased weight when the bushes are coming through would appear to corroborate the fact.

It is therefore essential to endeavour to maintain and increase the vigour of the bushes, by suitable manurial treatment, and by taking precautions, not only to check wash, but to allow of an adequate amount of cultivation to be done without increasing the loss by wash. Cultivation is essential for two reasons. First, to remove competition by weeds, and to aerate the soil. Second, to harry the insects during the stages they pass through in the soil. The deeper the cultivation which can be done, and the more frequently the soil can be turned over, the better with regard to thrips. Men of experience and merit, such as the late Mr. Christison and Mr. Claud Bald, have condemned rains cultivation, *but purely on account of wash.* No fault can be found with their recommendations. It is a matter of common sense. If, however, wash can be checked a little cultivation can be increased a little. Methods of wash prevention must be developed. The damage cannot be entirely repaired by manuring, because wash means the death of surface feeding roots. Neither can it be entirely repaired by topdressing. Roots, once dead, have to grow again, and topdressing, in any case, is futile so long as wash goes on. No sensible man puts his money in a pocket with a hole in it. He repairs the hole.

The prevention of wash is essential, and to such an extent that adequate cultivation can be carried on. Cultivation on wrong lines may be bad, but lack of cultivation is worse, and, with thrips in the offing, fatal. There are bushes at Tocklai, in the plains, on the same soil as, and within 150 yards of, tea yielding 15 maunds per acre, and which are never cultivated, being merely sickled when the jungle becomes excessive. These bushes do not give half a maund of tea per acre per annum, quite apart from thrips. How, then, can tea be expected, under the conditions obtaining in the higher parts of Darjeeling, and with cultivation reduced to a minimum on account of wash, to grow so vigorously as to give a good yield and throw off the attack of thrips? And, under these conditions, is it entirely an entomological problem?

The time taken by the insect to attain full development varies, in different individuals, from 18 to 32 days. It therefore follows that there is a considerable overlapping of generations, and indeed the insect may be found in all stages on any day throughout the season. It is not, therefore, possible, to take advantage of the insect being at any particular stage of development at any particular time, when devising means of control. Should it be the case, however, that the insect spends the cold weather at rest in the soil, the deep digging recommended as putting difficulties in the way of its development during the season will have still more to recommend it.

Both eggs and insects are removed and destroyed in large numbers when the bushes are plucked, and here, again, it is obvious that the slower the growth, and the longer it takes the leaf to mature, the greater are the chances of the insect of attaining maturity, and propagating its species, without thus being collected—still another way in which lack of vigour in the bushes affects the question.

Methods of trapping the insect on the way from bushes to soil, and soil to bush, which have often been suggested, do not appear to be feasible, as the insect drops from the bushes to the soil, and flies from the soil up into the bushes.

The insect may be destroyed in large numbers by the application of insecticides, but it is not possible, by this means, to destroy either the eggs, which are buried in the leaf tissue, or the pupae in the soil. The efficient use of insecticides demands a very fine spray, so that all machines and nozzles need to be in very good order, and the machines need to be properly pumped up. Unless this matter be attended to the results of spraying are bound to be disappointing, as the spray will not penetrate to the sheltered situations frequented by the insects. Spraying, without steps being taken to increase the vigour of the bushes, is likely to be disappointing in its results, and the latter should come first and spraying follow after. Prevention of wash first, careful but adequate cultivation next—accompanied by the judicious use of suitable manures where necessary—proper attention

to these matters will gradually enable the bushes to more than hold their own ; and, for those who lack faith in the ultimate value of these measures alone, or who wish to make sure that they are decreasing the numbers of the insects as well, the application of whichever of the insecticides referred to is cheapest and most readily obtainable.

Such, in the opinion of the writer, are the lines on which the thrips problem will be most successfully approached.

In conclusion, we are now aware of the fact that the damage done to the tea is confined to one species, the common thrips, and that the black thrips, far from being an enemy, is a friend in that it feeds on the common thrips. Measures such as cleaning lichens and mosses from the stems, the application of soda-washes, and the application of insecticides, will tend to the destruction of the black thrips, but, as will be seen from the records of daily collections, this insect, even under the favourable conditions in which it existed where the collections were made, is small in numbers, the number captured amounting to only 1½ per cent. of the number of the common thrips. Since its numbers are so small, a large percentage will escape destruction by such measures, so that when they become necessary from the point of view of the vigour of the bushes or of dealing with common thrips generally, no thought of their interference with the black thrips should be allowed to prevent their being carried out.

NOTES.

Tests of Insecticides against Red Spider.

In the course of testing insecticides sent to Tocklai for trial, in May last, an experiment was carried out against red spider, the results of which are now published for information.

The insecticides tested were :—

"Harola"—a lime-sulphur preparation, marketed by the Secretary of the Agri-Horticultural Society.

"Harbas"—a red-oil emulsion marketed by the same gentleman.

"Clensel"—marketed by J. F. Cameron & Co., Mercantile Buildings, Calcutta.

Lime-sulphur—home-made, according to the formula published in *Notes on the Spraying of Tea*.

The tests were carried out in the field, and an estimate of the percentage of the mites killed was subsequently made. The figures, which speak for themselves, are given below :—

Insecticide.	Strength.	Percentage of mites killed.
Lime-sulphur ...	1 part stock solution 10 parts water	83½
Harola	⅝ % in water ...	86
,, ...	⅝ % ,, ,, ...	90
,, ...	5 % ,, ,, ...	94
Harbas	⅝ % ,, ,, ...	76
,, ...	⅝ % ,, ,, ...	86
,, ...	5 % ,, ,, ...	81½
Clensel	3 % ,, ,, ...	92½
,, ...	5 % ,, ,, ...	95

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